Archaeological evidence for the development of Royal Naval gunnery from 1545 – 1811; analysing change through technology and culture

By

Daniel Pascoe

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Abstract

This research investigates the archaeological evidence of naval gunnery, primarily from shipwrecks of the Royal Navy from the Early Modern Period (1545) to the Industrial Revolution (1811). It focuses on five main case studies, the *London*, *Hazardous*, *Invincible*, *Colossus*, and the *St George*, which were apex fighting ships that represent significant periods in the development of the Navy. The guns were the *raison d'être* of these ships and so their design and fighting tactics developed to make best use of the guns. The guns, however, are only one component of an intricate array of equipment, tools and munitions that make up a naval gunnery system. The guns alone, therefore, do not tell us how and with what skill they were operated; it is the equipment and organisation of the gunnery system that provide this critical information and is the focus of this research. Investigation of these shipwrecks includes the analysis of new archaeological data, fresh from the most recent underwater excavations and surveys and, consequently, this thesis presents the most current research on the topic. These sites, studied as a collective, alongside other secondary sites and in conjunction with the historical record, chart the key developments in British naval gunnery throughout the study period and bring all the available data under one coherent study for the first time.

Developments were broken down into two main categories: technological, through improvements made to existing equipment or new inventions critical in the operation of the guns; and cultural, through identifying improvements in the management of the gunnery system ashore and in the organisation, maintenance and operation on board ship. The focus was thus on the gun's equipment, its context within the ship and relationship with other objects, rather than the guns or the design of the ship.

This research has shown that technological developments were in most cases minor, focusing on refining the gunnery system to make it more reliable, efficient and deadly. This is attributed to the simplicity of the smooth bore muzzle loading (SBML) gun and that its basic form did not change. Where this research stands out is that through a detailed analysis of the archaeological evidence one can see more than just form and function. Through unique details, such as tool and wear marks, or alterations and adaptations, the objects and structures provide a connection with the individuals that made and used them. This provides insights

into the people directly involved at key points throughout the development of the Navy, identifies the everyday challenges they encountered and, most importantly, the methods and techniques they used to overcome these problems, from the ad hoc to documented specifications. As such, this original contribution to knowledge does two key things: first, it provides a chronology of technological developments through the analysis of equipment and its context—much of which was collected for the purposes of this research—and, second, these results allow us, as archaeologists, to take the technological details and imbue them with cultural context. It is these crucial details that separates this research from previous historical work on the topic.

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You cannot do maritime archaeology on your own, it is all about teamwork, from the people who drive and crew the boats that get you to site, to all the divers investigating the archaeology from the seabed, through to the many volunteers, finds specialists and conservators that process and finally conserve all the artefacts. I am grateful to all who have worked alongside me but I would like to express a special gratitude to the following:

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Michael, for introducing me to the fantastic underwater world of shipwrecks at the age of 14, which ultimately led me to where I am today.

List of Abbreviations

BL – British Library

BNF – Bibliotechque National de France

BU – Bournemouth University

CA – Cotswold Archaeology

CIFA – Chartered Institute for Archaeologists

CSPD – Council of State Papers Domestic

CISMAS – Cornwall and Isles of Scilly Maritime Archaeology Society

DSV – Dive Support Vessel

FFM – Full Face Mask

HCCA – Hampshire County Council Archives

HE – Historic England

HM – His/Her Majesties

HMS – His/Her Majesties Ship

HPG – Hazardous Project Group

IJNA – The International Journal of Nautical Archaeology

JOS – The Journal of the Ordnance Society

MAST – Maritime Archaeology Sea Trust

MAT – Maritime Archaeology Trust

MBES – Multi-beam Echo-Sounder

MNM – Museé National de la Marine

MRT – Mary Rose Trust

NAS – Nautical Archaeology Society

NMM – National Maritime Museum

NMRN – National Museum of the Royal Navy

PA – Pascoe Archaeology

RCT – Royal Collections Trust

RAI – Royal Artillery Institution

RUSI – The Royal United Service Institute

SCUBA – Self Contained Underwater Breathing Apparatus

SBML – Smooth Bore Muzzle Loading/Loader

TNA – The National Archives

WA – Wessex Archaeology

Table of Contents

Index of Figures

Index of Tables

Chapter 1 Introduction to the thesis

1.1 INTRODUCTION

This research critically investigates the archaeological evidence of naval gunnery, from the rise of a fighting fleet to the period of its global dominance, to establish, from a cultural and technological perspective, the development of the organisation of the Royal Navy through its evolving weapons system. Beginning in 1545 with the evidence from the *Mary Rose,* the earliest known site of a fighting ship with water tight gunports and a fully integrated weapons system (Hildred 2011), it ends in 1811, with the evidence from the 2nd rate ship of the line, the *St* George. The *St George* represents the peak of the smooth bore muzzle loading (SBML) weapons system, a defining technology of the study period soon to enter its twilight years after the introduction of iron ships in the 1850s requiring the development of rifled guns with the power to penetrate these new hulls (Hogg and Batchelor 1978, pp. 43–71). Despite minimal change in the design of the SBML gun from 1545 to 1811, great strides were made in its manufacture, supply of equipment and munitions, as well as in its operation by the crew and strategies to make best use of it. The physical evidence of these developments have both technological and cultural implications and survive within the wrecks of the Royal Navy, the focus of this work.

Shipwrecks are a product of a catastrophic event, whether it be by natural disaster, human error or by direct conflict. As a result, what is found on the seabed by archaeologists is the nearest one gets to a snapshot of an exact moment in time; the shipwreck provides a dateable context for the artefact remains on board. The archaeology, therefore, identifies what was there, rather than what should or is believed to be there (Muckelroy 1978, p. 215). It is also important to remember that even on the most well-preserved shipwrecks, at various points since being submerged, they have been impacted by the physical and biological marine environment, or even by contemporary or modern human interference. All of these factors will have affected the archaeology surviving today (Ortiz-Vazquez 2018, p. 2). It is vital, therefore, to have good understanding of the vessel's entire life cycle.

The archaeological evidence gathered for this research comes predominantly from recovered assemblages of gunnery equipment. In some cases, but by no means all, from within well-preserved structural remains of the ship. Where structures do exist and have been recorded, this study will link the objects to their context and use within the ship. Whilst the focus is on ships of the Royal Navy, where evidence is sparse complementary records from ships of other origins are included to aid interpretation.

The principal function of a warship was to provide a mobile platform to either attack or defend against an enemy. Initially the crew were the primary weapon on the ship and the gun was secondary; the crew were used decisively to board the opposing vessel and fight hand-to-hand combat, essentially fighting a land battle at sea (Trollope 1994, p. 25, Hocker 2015, p. 63, Warming 2020a, p. 99). However, as the potential of the heavy gun at sea was realised the guns would become the primary weapon to defeat the opposing ship. The gun that dominates this entire period is the SBML gun and its basic form does not change. What does change is the way these guns were brought to bear via the vessel and tactics, the potency of the propellant driving the projectiles, and the operation of the guns by their gun crews by use of equipment and by the crew obeying commands and drill.

The developments in naval gunnery during the first hundred years of this period are reflected by significant changes in ship design and fighting tactics. Henry VIII's *Mary Rose*, known as a carrack or 'Great Ship' was later adapted to carry a large number and variety of guns (Hildred 2011). When originally constructed the *Mary Rose* had performed with distinction and exhibited both considerable speed and manoeuvrability (Adams 2013, p. 112). By the time of her wrecking her armament had been increased; during her final stage she boasted a large number of great guns as well as smaller anti-personnel weapons. This reflects the fighting tactics that are clearly at a transitional stage between the use of heavy guns at range and smaller weaponry used in the traditional fashion to achieve a decision by boarding (Hildred 2011, p. 854).

The large carracks were not the only vessels in Henry's navy. This was a period of experimentation in vessel types and design in the search for the ultimate warship (Wilson 2014, p. 84). Depicted in the Antony Roll of 1546, a manuscript illustrating and listing naval ships, ordnance and other equipment, are several dual propulsion medium sized vessels (Knighton and Loades 2000). These vessels, known as 'galleases', combine the agility of the Mediterranean oared galley with the more robust and heavily armed sailing ship of northern Europe (Adams 2013, p.112). Henry was attempting to create a versatile navy with the capability of fighting in all maritime arenas (Wilson 2014, p. 84).

During the reign of Elizabeth I, master shipwrights such as Matthew Baker, Peter Pett and Richard Chapman combined the qualities of the two types of vessels and produced a low, sleek, highly manoeuvrable and heavily armed vessel, known as the ‘Elizabethan galleon’ or ‘race-built galleon’ (Wilson 2014, p. 92). These vessels, alongside a heavy broadside mounted on compact four wheeled carriages, were instrumental in defeating the Spanish Armada in 1588. The English captains used their faster and nimbler ships to great effect, bringing them into range of the Spanish ships and unleashing a bombardment from their heavy guns (Martin 1984, p. 368). The tactic would be repeated following disengagement to reload. The exercise of disengaging is a clear indication that the action of reloading was not rapid. It was with the widespread adoption of broadside gunnery and line-of-battle tactics by the mid-17th century that the need grew for a rapid, efficient and effective gunnery system. As a result, methods of working the guns were adapted and improved to increase the rate of fire. A rapid rate of fire at close range would become the main objective of a ship of the Royal Navy to win the fight against an enemy ship. To achieve this, however, would take great discipline and training (Rodger 1996, p. 59), the advent of which would only be seen with the later emergence of a professional and highly organised navy.

Information relating to gunnery can be found in contemporary naval administrational documentation or inventories of ordnance stores. This type of information is useful in that it generally provides reliable, factual evidence. The problem, however, is that it lacks the detail that only the archaeological evidence can provide. As such, there has been much debate regarding the working of the guns at sea, particularly during the periods of the 16th and 17th centuries (Konstam 1988, Rodger 1996, Martin 2017). It was by no means mastered by then, as this research will show how tinkering continued well into the 18th and early 19th centuries. The guns themselves are robust objects and survive both on shipwrecks and in terrestrial collections. The guns, however, are only one component of an intricate array of equipment, tools and munitions that make up a naval gunnery system. The guns alone, therefore, do not tell us how and with what skill they were operated, it is their equipment and carriages that provide this critical information, with the greatest evidence for this coming from shipwrecks.

The benefits of focusing on the archaeology is that the small details found on the actual objects or parts of the ship, such as tool and wear marks or alterations and adaptions made to equipment, provide the clues to the everyday challenges of operating the gunnery system and how the individuals on the ships improvised to overcome these problems.

The survival of such material usually, but not always, occurs when sections of a ship survive in their burial environment. A prime example of this is the *Mary Rose*, which is where this study is introduced within the literature review in chapter two. Since the recovery of the *Mary Rose* in 1982 many other wrecks of the Royal Navy have been investigated, albeit in most cases to a lesser extent. Even so, significant assemblages of gunnery equipment have emerged from sites across the relevant study period and up to the wreck of the *St George* (1811), the last case study in this research. This research will explore the archaeological evidence from these sites, in conjunction with a critique of the iconographic and historical evidence, to identify key developments but also the routine and unique behaviours or habits of those maintaining and operating the guns. It is the latter details that make this research standout from previous studies that have focused on historical sources and the guns alone. As such, this research will draw heavily on primary archaeological data recently discovered from five main case studies: the *London* (1656-1665), the *Hazardous* (1698-1706) and the *Invincible* (1747-1758), the *Colossus* (1787 – 1798) and the *St George* (1785 – 1811). This new evidence will fill gaps in the existing record and shed new light on the development of naval gunnery.

With the exception of the *St George,* I have been fortunate to have dived and worked on the other four case studies, as well as several other secondary sites that feature in this thesis. Although some of these sites have been the subject of recent excavations, managed and planned as separate projects by other organisations and institutions, my involvement goes back much further and is ongoing; either as Licensee, lead archaeologist or a team member. As such I have been gathering a wealth of material and primary data from these sites for the last 14 years. Perhaps fortuitously, but not surprisingly, a vast amount of this has been related to gunnery. This richness in gunnery material, across several sites and spanning three centuries, places me in a unique position to be able to bring it all together under one coherent study to enhance the understanding of English and British naval gunnery during the SBML era.

1.2 WHY IS THIS STUDY IMPORTANT AND RELEVANT?

Importance

To-date there has been no systematic archaeological study of the development of naval gunnery across the whole period. This research will bring together, for the first time, the available archaeological, historical and iconographic evidence from across the period into one coherent study. Gun equipment from the SBML era is particularly rare in the terrestrial collections as it was either discarded or recycled for other purposes when it became obsolete, the best evidence survives from shipwrecks. It is this equipment that provides the critical information on how the guns were operated. Crucially, much of the research will be drawing on fresh archaeological data recovered during the most recent shipwreck investigations, as well as utilising existing material and records from previous works. This research will therefore present new evidence that sheds new light on the study, augmenting our existing knowledge and interpretation.

Given the rarity of gun equipment in terrestrial collections and the recent nature of the shipwreck investigations relevant to this work, the archaeology of naval shipwrecks across the period is poorly represented in national museums' collections. The new material being investigated here will therefore fill many gaps in these collections, adding significant breadth to the future research questions that can potentially be addressed. Equally as important, however, is that the research carried out through this study will aid the interpretation of that material, further enhancing museums displays and dissemination. The details gained from studying the real objects, and the information from the context from which they were found, will help correct inaccuracies in some modern-day interpretations that have until now relied solely on historical records. The value of the archaeology is that it provides the physical connection with the individuals that created and operated the various facets of the naval gunnery system. Although those individuals were part of a highly structured naval society, which generally followed a system of rules and standards, sometimes changes in circumstances or problems within the administration or overall management of the gunnery system could lead to the improvisation and adaption of equipment by those directly involved. These improvisations and adaptions were often unique and not generally documented. It is these types of details lacking from historical treatises of naval gunnery and even contemporary personal accounts and which provide critical evidence for understanding the operation of the guns. As such, dialogue relating to this reinterpretation has already begun with the archaeologist of HMS *Victory* and curators of the National Museums of the Royal Navy.

This study is also important for future research as it will identify the gaps in knowledge that still exist in the archaeological record. It will illuminate the periods where there is a lack of evidence and inspire archaeologists to either seek out new shipwrecks or revisit existing sites to explore new areas that will potentially fill those holes in the record and allow this research to continue.

Relevance

The relevance of this work stems from the fact that it studies the sites of the Royal Navy as a collective and addresses gaps in the existing knowledge of naval gunnery. This has been made relevant and possible due to a surge in the investigations of shipwrecks in the UK, including several Royal Navy sites. These investigations include strategic excavation of several wrecks including the 2nd rate *London,* which blew up in 1665; the 4th rate *Hazardous Prize*, wrecked 1706; the 3rd rate *Invincible,* wrecked 1758; and the 3rd rate HMS *Colossus*, wrecked in 1798. The author has been directly involved in all these sites' investigations and lead archaeologist during the *London, Hazardous* and *Invincible* excavations.

As with the majority of intrusive work on sites in the UK these were threat-led. The seabed and seas around the UK are highly dynamic and when a site becomes exposed, they become vulnerable to the physical and biological environment. Thankfully in recent times, the UKs heritage agencies, primarily Historic England, have been proactive and heeded the advice of the dedicated team members of these sites. This has led to excavations to rescue artefacts and information before it is lost.

Historic England, who manage the UKs underwater cultural heritage out to the 12-mile territorial limit, have either directly funded these excavations or in the case of *Invincible* have funded the research leading up to the excavation and offered assistance through granting an excavation license. The recent work on these sites have led to recovery of hundreds of artefacts and recording of structures relating to the ordnance on board these vessels. These sites represent nearly 150 years of the history of the Royal Navy and in that time there have been many changes and developments to the naval gunnery system. Much of these developments are present in these sites. The information that has emerged is the most current and has shed new light on the subject of naval gunnery.

Of course, these are not the only sites forming the basis of this research: there are more sites in the UK, and even more worldwide. Each site provides different pieces of the jigsaw and some more than others. It is important that they are studied as a collective rather than in isolation, facilitating the identification of key developments over time and an understanding of why things had to change. Equally as important is identifying the things that do not change, showing successful, workable adaptations. Given the plethora of evidence now available, it is essential that all the archaeological evidence of naval gunnery of the Royal Navy be brought together under one coherent study.

1.3 Aims and objectives

1.3.1 *Aims*

Through the archaeological evidence from the wrecks of the Royal Navy this research aims to enhance the understanding of naval gunnery from key developments to everyday routines and habits. During this process it will identify changes in culture and behaviour from the top, with the naval administration, down to the individual ships and their crews, assessing the relationship between the archaeological and the historical record.

It will also aim to reveal, from the surviving artefacts and wrecks themselves, the technological changes that led to improvements in the naval gunnery system. It will therefore focus on the gun's equipment, as this is not only where the greatest evidence across the whole period of study is found, but these elements are vital in understanding gun capability and the skills of the crew. Moreover, as these artefacts rarely survive on land, the evidence provided by shipwrecks offer a unique opportunity. Of course, where structures—specifically gun bays and storage areas—of a wreck have been recorded, this information will also be incorporated.

It is similarly important to understand the supply and organisation of munitions, powder and spare equipment on board to keep the gunnery system working. As such, this research will study the physical evidence of storage and distribution of these items, where evidence survives, revealing any changes over the period. Additionally, it will investigate whether the way these supplies were stored and organised reflects shipboard culture and behaviour, and whether this also changes through the period in question.

The above aims have focused on understanding the operation of the guns in relation to their use during or in preparation for conflict. However, much of the time on board a ship was spent in transit and simply sailing from one location to another. This research will therefore address this 'down time', aiming to find evidence for securing and maintaining the guns when not in use.

1.3.2 *Objectives*

1. Focus on five Royal Navy shipwreck cases studies, the *London*, *Hazardous*, *Invincible*, *Colossus* and *St George*. All of which represent stages of development across the study period and that can provide a rich and well-preserved source of archaeological material relating to gunnery.
2. Conduct underwater fieldwork to collect and analyse new archaeological material relating to naval gunnery;
3. Consolidate and analyse existing archaeological material related to naval gunnery that can be used to support and provide comparable evidence alongside the main case studies;
4. Conduct a thorough search of the historical record and critically analyse the relationship between it and the archaeological record;
5. Through a vigorous investigation of the material culture identify the equipment essential to the operation of the guns and look for changes and developments over time;
6. Through spatial analysis of the contexts in which the material culture was recorded identify how material relating to gunnery was operated, organised and maintained, and track changes over time;
7. Through the archaeological evidence identify changes in culture and behaviour within the naval administration and on board ship throughout the study period.

Chapter 2 Literature Review

2.1 INTRODUCTION

There is a large body of literature that provides the context for this research. This can be broken down into several categories which are addressed in sections 2.2-2.5 of chapter 2: Section 2.2 deals with contemporary writings which include technical and theoretical companions written by practising gunners; section 2.3 provides an overview of primary source material of the Naval Administration and the Board of Ordnance; section 2.4 critiques the most relevant modern day historical studies; and section 2.5 addresses existing published archaeological investigations and identifies the areas of the naval gunnery system they provide evidence for. Therefore, the disciplines of both history and archaeology are equally important to this research and their records will be critically investigated alongside each other throughout.

The beginning of this research broadly begins with the *Mary Rose*, lost in 1545. The site has been the focus of one of the most intense maritime archaeological investigations in the UK, which led to complete excavation of the coherent starboard side and its subsequent recovery in 1982 (Rule 1982). Since recovery, the hull has been conserved along with the bulk of the artefact assemblage recovered from within the hull. This has led to the publication of five volumes of research, including volume 3 Weapons of Warre, The Armament of the *Mary Rose*, edited by Dr Alex Hildred, Curator of Ordnance and Research at the Mary Rose Trust (MRT). The work led by Hildred identifies every facet of the naval gunnery system aboard a Tudor warship. As the research by Hildred was so comprehensive it will be reviewed within this chapter so as to introduce the earliest evidence of the English naval gunnery system and establish a structure of investigation to be followed when analysing the main case studies.

2.2 CONTEMPORARY WRITINGS

As an island nation the sea has always been Britain's link to the rest of the world, allowing it to reach all regions of the globe, but it was also the first line of defence. Threats to the country came from the sea and, because of this, the ruling powers would invest a great deal in the navy to defend it. A key element of this was the gun, which came with the invention of gunpowder. In England, the gun would be rapidly adapted to be used on board ships. This occurred by adapting the mountings of the guns by replacing the two wheeled carriage with the truck carriage. The gun, specifically the SBML, would become the primary weapon in use for over three centuries (Caruana 1994, p. xi), with the art of gunnery rapidly developing throughout this time. As gunnery progressed so did the practice of operating the guns, which resulted in practicing gunners publishing their instructions on the best practise known to them at the time. Early examples were William Bourne who posthumously published *The Arte of Shooting in Great Ordnance* in 1587 and William Eldred who published *The Gunners Glasse* in 1646. Whilst highly useful historical documents, an issue with these early works is that they were written in highly theoretical terms as the science of gunnery and how it ought to be, rather than how it actually was (Martin 1984, p. 235).

As conflict at sea increased so did developments in ship design and naval gunnery. By the mid-17th century and the general adoption of broadside gunnery, along with line of battle tactics, the full potential of the gun at sea was being realised. Ships and fighting tactics were designed around using the guns decisively to destroy or capture the enemy ship. Once the tactics of getting the ships in the correct position, to make best use of the guns, was realised, the operation of working the guns becomes clearer. This is mirrored in the contemporary writings, where instruction manuals became more practical rather than theoretical. In the works of '*The Sea-Gunners Companion …*' by Captain Francis Povey (Povey 1702) the focus is on the practise of ordnance at sea. They include detailed description of the gun's equipment and even practical methods of adapting equipment to make them more functional. This reveals more information about how the guns were operated and problems overcome to get the best results. An issue with sources like this is that although they were written by the people that practised with the guns, they were often written during retirement from the service. As such, they are writing about how it was in their time rather than how it was at the time of the publication.

Gunnery manuals written by persons experienced in gunnery continued to be regularly published throughout the 18th and 19th centuries, examples were William Mountaine (Mountaine 1747), John Muller (Muller 1757) and Sir Howard Douglas (Douglas 1855). Comparing these manuals enables the tracking of changes in equipment and methods of operation over time and they help provide the reasons for or ideas of why certain aspects of the gunnery system changed.

2.3 Primary sources

There is no shortage of primary source material relating to naval ordnance in national archives spanning the entire study period. Many of the sources are administrational and provide accurate and reliable facts. There are inventories of ordnance stores from the Board of Ordnance, dating back to the last quarter of the 16th century, all the way through to the 19th century. These provide lists of guns and the equipment necessary for working the guns, and many are found in the WO55 series held at the National Archive (NA) at Kew. The study of these lists tells the researcher the types of equipment in use at a particular time. It is also possible to identify when certain equipment becomes obsolete or new equipment developed. In some cases, inventories of stores exist relating to named vessels. This is the case for the *Mary Rose*, through the Antony Roll (Knighton and Loades 2000) and the *London*, through the Chatham Ledger (TNA WO55/1675). These documents tell us exactly what was on board, or at least what should have been on board when the vessel sank, and enables a direct comparison with the archaeology.

Other useful administrative documentation belonging to the Board of Ordnance are the bill books found in the WO51 series at the National Archives (TNA). These include invoices and receipts for supplies and works carried out for the production of stores. Although they lack detail regarding their construction and use, they are extremely reliable and accurate sources that can help identify the relationship between written records and the archaeological evidence.

In addition to these administrational documents there are also original ship's plans, drafts, building and progress reports. Many of these plans and documents can be found at the ship's plans collection at the National Maritime Museum (NMM) or at the TNA. These provide the details of construction and in many cases the internal layout of the ships, which is particularly useful in determining where equipment, stores and munitions were located.

It is not always the case that a plan or report survive for a wreck under the investigation in this research. Quite often, however, a plan of a class of ship similar to one under investigation does survive, which can provide comparable evidence, but it is not always the case that internal layouts are completely identical for the same class. It is also important to remember that during a ships' life cycle it may have experienced rebuilds and refits. During these times the structure and internal layouts may have changed and therefore the remains found on the seabed may not always be a true representation of the ship in the original plan.

2.4 Secondary sources

The late Adrian Caruana published '*The History of Sea Ordnance 1523-1875'* in three volumes. His first two volumes are relevant to this study. This is a comprehensive study of naval gunnery using primary historical administrative records and extant guns predominately from terrestrial collections. In his first volume he covers the period starting from 1523 through to 1715, which he calls the age of evolution. The progress of English sea ordnance is tracked through the various monarchical dynasties. Both the title of his first volume and the way he divides the periods of developments is quite apt for this period. During this time frame, and particularly the first 125 years, the English navy like the other European powers were finding their feet in terms of naval gunnery and how best to use it. As Prof Jonathan Adams realises, the ships of the navy of this period were an opportunity to symbolise the power and status of the monarch and the nation (Adams 2013, p. 111); the gun and the number of guns were an ideal tool to demonstrate one's might. Thus, ships were constructed to mirror the image of how their rulers wished the rest of the world to portray them. This often conflicted with the original design of a ship and in some cases led to disaster. This was certainly the case with King Gustav II Adolf of Sweden's flagship, the *Vasa*. The King's wish for a greater number of guns and of the same size on both gundecks was a significant contributing factor to the ship's capsizing on its maiden voyage in 1628 (Cederland 2006, Hocker 2015).

Henry VIII is another example, who perceived himself as a warrior king and a navy with ships brisling with guns was an opportunity to demonstrate his honour and strength (Loades 2011, p. 2). By 1543 and the third war with France, the ships in his navy carried a far greater number of heavy ordnance than the navy of 1512 (Loades 2011, p. 2). Many of these additional guns were added during refits and would have led to significant alterations to their original designs. The *Mary Rose,* for example, was adapted and strengthened during her 1536 refit to accommodate the extra heavy ordnance (Dobbs et al. 2009, p. 365). As well as introducing lidded gunports close to the water line and installation of extra reinforcing timbers, the guns themselves and their location on the ship would have altered the way the ship reacted at sea. Although there is little evidence of the guns alone being at fault for her capsizing in 1545 (Hildred 2011, p. 915), the combination of this with other factors all probably contributed to the *Mary Rose* sinking. These factors include: the increase in ballast to compensate for the increase in weight high up from the guns (Marsden 2009, p. 392); increased weight distributed in the upper parts of the ship from extra soldiers; heavy objects stowed on the upper deck, including spare anchors and cables (Sanders 2019, pp. 60–61); the location of some of the heavy guns on the upper decks; and the possibility of the lack of experience of the crew in retracting the guns and closing gunports when manoeuvring (Marsden 2009, p. 392). Several of these issues appear to have been a knock on effect of the introduction of the large number of heavier ordnance.

Caruana's second volume titled '*the age of the system*' deals with the period from 1715 to 1815. By this time the potency of the naval gunnery system and how to engage it is realised. Now this is understood, developments occur to make it more deadly and efficient. Caruana marks the key developments during the major conflicts of the period as warfare directly drives the need for developing new technologies.

Although this study is full of reliable evidence, the historical documents utilised and the guns alone lack the detail that provide many of the answers to how, and with what skill, the guns were worked. It is the gun's equipment, carriages, and understanding the culture of the crew that used them that provide the critical evidence for operating the guns; this evidence primarily comes from archaeological investigations of shipwrecks and highlights the need for this research. It must also be noted that Caruana's work has not been without criticism from some fellow historians who have questioned the rigorousness and depth of investigation of his secondary and primary sources, as well as his historical analysis (Lyon 1997, pp. 354–356, Rodger 2005, p. 792). With that said, and taking on board the criticism, Caruana's two volumes still provide a very useful chronological background to English sea ordnance, which can be used as a springboard into the archives for further historical research.

Nicholas Rodger, a renowned naval historian of today, has published extensively on the history of the Royal Navy and, in doing so, tackled the subject of gunnery several times. In his article 'the development of broadside gunnery' he discusses fighting tactics and the method of reloading the guns as key factors in understanding the adoption of broadside gunnery as the primary means to destroy the enemy (Rodger 1996). However, he points out this does not coincide with the introduction of vessels capable of carrying and firing a broadside (Rodger 1996, p. 302).

We know from the archaeological evidence from the *Mary Rose* that ships were being constructed with watertight lidded ports on either side of the vessel from the first half of the 16th century (Hildred 2011, p. xxx). This allowed the *Mary Rose* to carry and fire several of her heavy guns from the sides of the ship. However, the tactics of this period were still to come alongside the opposing vessel and, by boarding and killing enough of the enemy crew, win the battle. The physical evidence of this is the variety and quantity of hand weapons, bladed, pointed and gun powder, found on the wreck of the *Mary Rose*. The heavy guns on the broadside were not intended to be the decisive weapon. The archaeological evidence supports this by demonstrating that despite the *Mary Rose* having trucked carriages there was insufficient room to allow several of the heavy guns to recoil into the load position (Hildred 2011, p. 900). Therefore, to be able to reload these guns the crew of the *Mary Rose* would need to disengage the ship from the enemy to either reload outboard or manoeuvre the guns diagonally in board to reload. It must be noted, however, that the *Mary Rose* was equipped with heavy breech loading weapons which would have allowed an option of continuous fire and this will be explored in more detail within section 2.5.1.2 of the chapter two.

So, although ships from as early as the first half of the 16th century were capable of firing from behind lidded ports on the broadside, it was not conducted by the familiar method where the gun is repeatedly fired and reloaded inboard on the recoil, as we see from the mid-17th century onwards (Rodger 1996, p. 311). Rodger goes onto explain that by the end of the 16th century the tactic was to fight at range (albeit at a close range) and in doing so fire the complete armament of the ship in succession. This meant firing the forward-facing guns (bow chasers) followed by the broadside guns and then stern battery (stern chasers), turn and engage the other side, before finally disengaging to reload (Bourne 1587, Rodger 1996, p. 306). This process would then be repeated when the guns were reloaded. This is the tactic the English used to great success during the battle against the Spanish Armada in 1588 (Martin 1984, Rodger 1996, p. 311).

The key to effective broadside gunnery during the later line of battle tactics is the ability to fire a broadside and reload quickly and repetitively. To do this, reloading inboard following the recoil of the gun into the load position was essential. The ability to reload inboard was in practise for some time before the introduction of the line of battle, which first occurred during the first Anglo-Dutch war, but when did inboard loading first occur? Rodger poses the question and Konstam also states it has been a question that has been generally ignored until archaeological evidence began to emerge from shipwrecks (Konstam 1988, p. 18). This is a key question to answer in the development of naval gunnery and will be addressed in the following work. Rodger discusses the thoughts of other historians and shares their historical evidence to back their theories.

Caruana was critical of the view that guns were originally lashed to the inside of the hull to stop the gun from recoiling and he argued that there was no evidence to support this (Caruana 1994, p. 25). However, the evidence that has emerged from the *Mary Rose* clearly shows several of the bronze muzzle loading guns did not have the space to recoil back into the load position (Hildred 2011, p. 900) and therefore they would have had to been secured fairly tightly to the inside of the hull to prevent them recoiling over hatch ways. Caruana's evidence for loading inboard following the recoil of the gun comes from an inventory from the survey of the Queen's Majesty's ships anno 1576, listing ropes for gun tackle (Caruana 1994, p. 26) and the issues of breeching rope in the issues of the Board of Ordnance accounts of the 1590s (Caruana 1994, p. 37). Although the equipment was most likely available to allow the gun to recoil into the load position from an early period—trucked carriages, breeching ropes and gun tackle—there was an issue with space on the gundecks.

Rodger himself draws heavily on the first-hand accounts of several experienced naval officers in action whose accounts suggest the backwards movement of the gun. For example, Rodger quotes an account written in a letter by Sir William Winter from 1588 where he states

''*a hurt that I had received in my hip, by the reversing of one of our demi-cannons in fight''* (Rodger 1996, p. 311).

Due to forces created by firing a gun there will always be a degree of recoil even if it is lashed securely to the side of the hull and if one was standing directly behind the gun it would not take much movement of a heavy gun to cause injury. So, the issue here is, first, just because there has been some reverse movement recorded it may not have necessarily reversed all the way back into an inboard loading position. Second, if for argument's sake the guns were allowed to recoil back into the load position, from these accounts it is very difficult to prove whether they relate to a standard practice or the practice of a few.

What we do currently know from the archaeological record is that the English naval ships were equipped in part with trucked carriages from at least the first half of the 16th century. The truck carriage is specifically designed for use on board ship as the trucks are mechanically inefficient and help break the recoil of the gun (Caruana 1994, p. xvii). The trucks also help manoeuvre the guns more easily in tight spaces and enable the carriage to be run up to the side of the vessel, allowing the barrel of the gun to extend a safe distance from the side of the hull (Konstam 1988, p. 17). The archaeological and historical evidence suggests the equipment was available to reload inboard during action from an early period but was not being used to its full potential until the 1650s. Both Rodger and Konstam point out that this was likely to be due to the shortage of crew inhibiting reloading during a direct action, meaning to carryout out more than one salvo would affect the capabilities of the crew to sail the ship during the fight (Konstam 1988, p. 18, Rodger 1996, p. 313). Also, until ships are being specifically designed to carry a large number of heavy guns on the broadside, and fighting tactics changed to suit repetitive salvos from the side batteries, then having the gun recoil back to the reload position was not a priority. The increase in the number of crew at each gun was also a crucial factor in the ability of repetitive broadside gunnery.

The first hundred years of gunnery were about finding the capability of the gun at sea and how to get it into position to create maxim impact and damage. Once this was realised the next 150 years were about maximising the effectiveness of the gun by making the whole naval gunnery system as efficient and deadly as possible. This was achieved through the rise of organisation, professionalism and discipline both on board the ships and ashore through the naval administration. The number of conflicts during this period leads to rapid developments in technologies and ideas and the expansion of the naval fleet. Of course, these factors were not unique to Britain, the other European super-powers were expanding their navies to be able to fight all over the world and developing new ideas and technologies of their own. So, what factors led to Britain having the edge in terms of gunnery over their rivals?

It would have been realised fairly early on that the accuracy of smooth bore guns at sea was an issue and therefore that the closer one gets to the target the better. Before the line of battle the general tactic would be to disengage following the first salvo to reload in safety. This changed with the development of the ship of the line and the line of battle. From this point, ships would come side by side, yard arm to yard arm and fire repetitively (Rodger 2005, p. 540). Coming in this close removed the issue of accuracy and keeping up a high rate of fire would generally bring success. The better drilled the crew was in firing the guns would tend to lead to a higher rate of fire. Rodger points out that it would have taken a high degree of nerve by the officers and crew to wait until the ship was as close as possible before firing, as while they were waiting, they were under fire themselves. Rodger attributes this ability of holding one's nerve to discipline and training (Rodger 1986, p. 59-60). From an archaeological perspective, however, finding the physical evidence for discipline and training is problematic, but we can find indirect evidence for it through the professionalism and organisation we see through the organisation of material culture that survives on shipwrecks, which is addressed through this research.

2.5 Archaeological

2.5.1 *The Mary Rose*

The most extensive research of an archaeological assemblage conducted on this topic and the benchmark for any subsequent study of shipboard weaponry is published in '*Weapons of Warre, the armament of the Mary Rose'* (Hildred 2011), The *Mary Rose* is the earliest surviving shipwreck with lidded gunports close to the water line, allowing the more stable carriage of heavy hull-smashing artillery. This was the technological breakthrough that would govern the ability to fight at sea for the next three centuries (Hildred 2011, p. xxx, Wilson 2014, p. 79). The ship thus represents a rapidly developing technology of the time with regard to her structure and also the equipment and weaponry she was designed to carry (Adams 2013, p. 73).

The *Mary Rose* was in action up until the moment she sank. This is demonstrated by the evidence of open ports—with the guns either loaded and run out, or, in the case of one of the wrought iron port pieces **81A3001,** in the process of being loaded (Hildred 2011, p. 156)—as well as equipment and ammunition scattered around at the gun stations; it is clear that the objects and space associated with working the guns were in use until that moment. Recorded within the original context of the ship, this evidence provides a direct link between the objects, the ship and the crew operating the guns; primary evidence for how the guns were operated on board a Tudor warship.

As Hildred points out from the beginning, the study of the armaments opens the path to discussion on many topics relating to gunnery, such as the technological developments of guns, their operation, organisation and supply of stores, and battle tactics (Hildred 2011, p. 1). This study of the ship's armament therefore covers every aspect of the naval gunnery system from the earliest evidence of a fully integrated weapons system found on board a shipwreck. In addition, through the survival of the Antony Roll, an inventory of ships and their stores, it also studies the relationship between contemporary historical records of the *Mary Rose,* with the physical evidence from the ship.

The archaeological evidence has shown that the *Mary Rose* was armed with an array of cutting-edge gun powder weapons, which included bronze muzzle loaders such as cannon, demi-cannon, culverin and demi-culverin. These highly decorative but powerful pieces peered menacingly through the hull from castle deck down to main deck (Hildred 2011, pp. 17–123). Sharing the decks among these show pieces were the more familiar 15th and 16th-century weapons, the wrought iron guns from the large port pieces on the main deck to the smaller slings and fowlers on the upper deck and half and quarter slings and bases of iron on the castle decks (Hildred 2011, pp. 130–285). The combination of these guns and the arrangement of gunports gave the *Mary Rose* the capability of engaging the enemy at long, medium and short ranges from all arcs of fire and with a variety of projectiles (Hildred 2011). When used at the correct distance, these projectiles could inflict devastating damage to both ship and personnel.

Critical to the performance of these guns were several key factors which include the equipment used to mount and operate them, the space in which to manoeuvre and control them and the supply and organisation of the projectiles and propellant. These will be key factors discussed throughout subsequent chapters of this research for identifying the developments in naval gunnery and will be discussed here in relation to the *Mary Rose.*

2.5.1.1 Transition to the armament of the *Mary Rose*

The *Mary Rose* was armed with essentially two types of artillery, wrought iron breech loading and cast bronze muzzle loading (with one exception of the anti-personnel weapon, the hailshot piece, cast in iron) (Hildred 2011). This battery of guns was a mixture of old and new technologies marking a transitional period in the arming of warships and the tactics used to make best use of the weapons system. The following examples provide the context within which the armaments on the *Mary Rose* came about. Written evidence of the purchasing of a gun for the English Royal ship, *All Hallows Cog*, in 1337, and the employment of guns in the naval battles of Arnemuiden (1338) and Sluys (1340), indicates that gunpowder weapons had been in use in Northern Europe on board ships from as early as the 14th century (Friel 2003, p. 72, Hildred 2011, pp. 12–13, Warming 2020a, p. 113). It wasn't until the second half of the 16th century, however, with improvements in the mounting of guns and the introduction of lidded gunports close to the water line, that their impact in naval combat was being appreciated (Howard 1986, p. 439, Hildred 2011, Warming 2020a, p. 113).

Prior to the introduction of lidded gunports, guns were more commonly of lighter anti-personnel types. These would be mounted on a metal swivel yoke and peg (Smith 1988, p. 6) and slotted into a hole on the rails of the upper parts of vessels, or, for larger calibre guns, mounted on wheeled carriages in the waist. (Friel 1995, pp. 153–4, Hildred 2011, p. 928). The latter are depicted in the Warwick Roll drawing *c.* 1485 on an armed four masted vessel (Figure 2.1). For reasons of stability and space these vessels were limited by the number of heavy guns they could carry in these areas of the upper hull. Thus, the vast majority of guns on board ships during the late medieval period were the lighter type, used as support for the hand-to-hand combat forces employed during the primary action of boarding an enemy, or indeed repelling marauders, rather than the sinking of ships (Hildred 2011, p. 928, Warming 2020a, p. 113).

Figure 2.1: A four masted ship in the Warwick Roll showing large calibre guns in the waist c. 1495. Image from Ian Friel's, The Good Ship (Friel 1995, p. 155) .

Some of the earliest archaeological evidence of this comes from the wreck of the *Gribshunden,* the flagship of the Danish King John I, lost in 1495 (Warming 2020a, p. 99, Rönnby 2021, p. 10). Archaeological investigations have identified that *Gribshunden* was a carrack armed with wrought-iron swivel guns. These were mounted on wooden beds, and fitted with iron swivel yokes and pegs (the iron yoke and peg has not survived but the transverse hole survives through the bed, where the yoke attached) and directed by a wooden tiller extending from the rear of the bed. These would have been located at several positions along the sides of the upper and castle decks. The discovery of a large perforated timber, believed to have been originally located along the side of the port or starboard side between the bow and stern castles would have served this purpose (Warming 2020b). Several guns have been recovered from the wreck along with their wooden carriages (Warming 2020a, p.

114). These weapons, loaded with round or canister shot, would have been extremely effective at clearing the enemy's deck before the primary action of boarding.

The archaeological evidence from the *Mary Rose* shows the ship was still very much equipped to carryout similar tactics when at close range, during the final phase of an attack. A large number of a similar type of weapon, known as bases of iron, were recovered. Instead of being mounted in a wooden bed, however, the iron swivel yoke with peg simply pivoted around a pair of trunnions and the gun was directed by a metal tiller extending from the rear of the gun. These were designed to be loaded, aimed and fired by a single person (Hildred 2011, p. 221). The loss of the wooden bed would have decreased the weight of these guns considerably and made them easier for one person to handle. The archaeological evidence from the *Mary Rose* shows that these guns were positioned along the sides of the castle decks via holes in the sills and railings into which the iron peg of the swivel yoke slotted (Hildred 2011, p. 235). In this respect, therefore, relatively little had changed from the time of the *Gribshunden.* The leap in naval combat is really seen in the introduction of lidden gunports, giving vessels greater capability of carrying heavier guns from a more stable and effective firing position on the ship and therefore greater potential of causing structural damage to other ships (Wilson 2014, p. 84).

Early evidence of larger artillery for use against ships, albeit from an Iberian vessel, comes from the recent excavations of the wreck of the *Esmeralda*, a Portuguese nau, wrecked in 1503 on the island of Al Hallaniyah, Oman. The *Esmeralda* was one of three heavily armed nau in a squadron of five ships, including two smaller armed caravelas. They formed part of Vasco da Gama's larger fleet during the second voyage to India (Mearns et al 2016, p. 331). The works of a contemporary chronicler, Gasper Correar, writing in the 1550s, described that the caravelas and ships (Nau) were equipped with a combination of large calibre artillery and smaller anti-personnel guns spread over the upper and castle decks, with many of these firing from the sides of the decks (Padfield 1973, p. 25, Blake and Green 1986, Barker 1996, p. 56).

The fleet used their guns to great effect in the defeat of an Arab fleet off the Malabar coast of India in which the Portuguese fleet formed in a line and fired repeat salvos from their heavy artillery along their sides (Padfield 1973, p. 26). This demonstrated that the Portuguese were considerably advanced in their tactics, placing their ships in a formation that made best use of their heavy artillery during fleet-against-fleet action (Barker 1998, pp. 113–14). This was a tactic that wasn't generally practiced in northern Europe until the mid-17th century. The variety of heavy artillery carried by these early Portuguese ships is now being corroborated by the archaeological evidence found on the wreck of the *Esmeralda*.

On the wreck site of the *Esmeralda* a large assemblage of munitions were found belonging to several types of anti-ship and anti-personnel guns. Except for three bronze barrels, belonging to a type of handgun, no other guns were found. Historic records have revealed that the guns were salvaged by the surviving crew, immediately after the wrecking event (Parham and Cousins 2015, Mearns et al. 2016, p. 333). Among the assemblage of munitions were 91 round stone shot and 71 cast iron round shot in several sizes, demonstrating that the *Esmeralda* was equipped with different types and calibres of anti-ship guns (Figure 2.2) (Parham and Cousins 2015, pp. 18–19, Mearns et al. 2016, p. 338). The largest, 220mm in diameter, belonged to a gun known as a camelo, the standard high calibre gun for shipboard use in Portugal (Barker 1996, p. 59). They were generally 18-pounders with a 190mm bore but the recovery of a bronze muzzle loading gun from another Portuguese wreck, *Sao Bento* with a 230mm bore and camel insignia suggest they went as high as a 32-pounder (Blake and Green 1986, Barker 1996, p. 60). The Portuguese were also attacking coastal towns during the campaigns in India and it is likely the largest calibre weapons were also used like siege guns to bombard these coastal targets. An example of this was the bombardment of Calicut in 1500 (Barker 1996, p. 55).

Figure 2.2:Examples of the variety of shot recovered from the Esmeralda. The largest up to 220mm in diameter (Photo by author).

Due to the size of the camelos they would have had to be fired from the waist of the vessel like on the ship depicted in the Warwick Roll. The gunnery tactics of the Portuguese may have been advanced for their time, but the hull structure of their ships was not strong enough to cope with repetitive fire from heavy artillery. Correia described that the bombardment of Calicut was meant to continue for several days but the masters of the ships would not allow it to continue because of the damage being caused by the stresses on the hull from the firing of the guns (Barker 1996, p. 55). The stresses on the hull and the burden of extra weight is why the *Mary Rose* was re-enforced with additional diagonal and vertical bracing along the entire length of the hull below the main deck (Marsden 2009, p. 380, McElvogue 2009, p. 98). Having such heavy objects high up on the vessel also causes issues of stability and this is perhaps one reason why the Portuguese were known to stow guns below during ocean passages and mount them when they reached Indian waters (Danvers 1894); it is likely that these guns were only brought up when needed. Potential physical evidence of this emerged from the wreck of another 16th century Portuguese vessel wrecked on a reef in the Seychelles.

Diver observations noted a group of 10 bronze guns in a 'tidy heap' suggesting they had been stowed in the hold (Blake and Green 1986, p. 10).

The length of the largest muzzle loading camelos would have made loading inboard challenging and they were either manoeuvred to face forward or aft after firing or loaded outboard by shimming out along the chase of the gun. The latter would have been both slow and precarious. Therefore, repetitive salvos may have come from the shorter and lighter medium calibre artillery. The recovery of 19 bronze and one iron breech chambers along with nearly 1000 composite lead and iron dice shot for swivel guns demonstrates that the *Esmeralda* was also adequately equipped for the more traditional close quarter tactics ending with boarding the enemy vessel (Figures 2.3 and 4). The fact that there is more than 80 percent more shot for the anti-personnel weapons than the anti-ship guns shows the tactic of come alongside and boarding was still the preferred method of finishing the fight.

Figure 2.3: Two bronze breech chambers for swivel guns in-situ on the wreck of the Esmeralda (Photo by author).

Figure 2.4: Several examples of the breech chambers recovered from the wreck of the Esmeralda (Photo by author).

Prior to the 1536 refit the *Mary Rose* would have been armed in a similar fashion to the *Esmeralda*, in that there would have been a far greater number of light weight anti-personnel guns, but the *Mary Rose* was mainly equipped with wrought iron pieces instead of bronze. The 1514 ordnance inventory for the *Mary Rose* recorded 65 wrought iron pieces out of a total of 78 guns (Hildred 2011, p. 7). The introduction of lidded ports on the *Mary Rose's* main deck along with the added bracing was the formula for carrying heavier ordnance.

2.5.1.2 Operation of the *Mary Rose* guns

The archaeology of the *Mary Rose* has shown that the heavy ordnance consisted of an organised mix of bronze muzzle loading and wrought iron breech loading guns. The large wrought iron guns included port pieces, which were mounted on a solid timber bed with two wheels and an elevation post at the rear. The guns were secured by breeching ropes, which fed through a hole in the rear of the bed and through ring bolts on the inside of the hull. Loading at the breech meant the gun did not need to be withdrawn back to be loaded, but could be loaded within the safety of the hull. The discovery of shot and pre-loaded breech chambers within the gunbays of two of the port pieces demonstrate that the guns were prepared for an immediate reload and therefore showed the potential for repeat salvos (Hildred 2011, pp. 173–4).

Four of the seven guns on each side of the *Mary Rose's* main deck were port pieces. They had a bore of eight inches and fired a solid stone shot with hull smashing capabilities, or canister shot with devastating effect at short range on personnel or rigging. This was demonstrated by replicating and then firing one of the *Mary Rose's* port pieces at a reconstruction of the side of the hull, loaded separately with stone and canister shot. The former demonstrated its effectiveness at penetrating wooden hull structure and the latter had a deadly spread recorded at 4m over the target (Hall 1998, pp. 57–67, Hildred 2011, pp. 285–90).

The port pieces on the *Mary Rose* are the earliest example in England of a movement towards the standardisation of a large number of a particular type of heavy gun to a gundeck (Hildred 2011, p. 926) and historical research has demonstrated that this was not unique to the *Mary Rose.* A list of ten ships from 1540, including the *Mary Rose,* with an inventory of armament shows that of the larger calibre guns the wrought iron port piece made up the main armament of all but one of the ships (Smith 1993, p. 6). The high concentration of these guns demonstrates that there was a clear tactic in the English navy during the mid-16th century to fight at medium to short range (Smith 1993, p. 8, Hildred 2011). Having entire sides of one calibre of gun to a deck would not be achieved until the late 17th century.

The *Mary Rose's* upper and castle decks were equipped, in part, by smaller wrought iron guns. These areas of the ship were accessible to Tudor and 19th century salvors and, as a result, the evidence of these guns is less complete. The surviving evidence, however, does identify at least two types of medium sized wrought iron guns on the upper deck, the sling and the fowler. One whole example of a sling survived at its gun station pointing through a semi-circular hole above the gunwale, complete with carriage and spare chamber (Hildred 2011, p. 204). Like the port pieces, they could be loaded with either round shot for targeting the opposing ship at medium range or canister shot targeted at personnel or rigging at short range. There is a great advantage of having high numbers of wrought iron guns located on all the gundecks as it gave the ship the capability of continuous layered fire, which could begin at medium range and continue at close range in support of the final acts of boarding the opposing ship.

The large muzzle loading guns on board the *Mary Rose* were all bronze, mounted on four wheeled carriages and secured to the side of the hull via breeching ropes. Due to lack of deck space behind the guns, not all would have been allowed to recoil back into a position where they could be loaded entirely within the safety of the hull. Instead the breeching would be tight and would have needed to be untied to enable the guns to be drawn back to load. Six of the ten bronze guns recovered were associated with their carriages (Hildred 2011, p. 37). The carriages are not identical but they share several key characteristics, including a bed, two trunnion support cheeks made of elm, front and rear axles made of ash and four solid wheels, known as trucks, also made from elm (Hildred 2011, p. 39). These are the earliest examples of a type that would become the standard sea service carriage for the next 300 years. These carriages were more compact in comparison to land service guns and the wheels relatively small and solid, designed to be purposely inefficient to help retard the recoil of the gun, essential for operating heavy guns in restricted space. This feature would be especially useful on a ship with minimal deck space that was not originally designed for these types of guns.

These carriages were a great advantage over the two wheeled carriage, which featured much larger spoked wheels and a long trail for stabilisation. These two-wheeled carriages had more in common with land service carriages and required more space to manoeuvre and operate. Despite their unsuitability for sea service they were commonly used by other navies until the end of the 16^{th-} century. Archaeological evidence of this type of carriage comes from the wrecks of the Swedish warship *Mars*, which blew up in a battle against a combined Danish and Lübeckian fleet in 1564, only a year after it was launched (Eriksson and Rönnby 2017, p. 92); the 1588 Spanish Armada wreck of the *Trinidad Valencera* (Martin and Parker 1988, p. 210, Parker 1996, pp. 281–282)**;** and, most recently, the wreck of Spanish galleon *Santiago de Galicia*, lost in 1597 (Personal communication Christin Heamagi from the Maritime Archaeology Trust and team member of the Santiago Galicia project).

Archival research has discovered that the *Mars* was armed with four large wrought iron pieces and up to 112 bronze guns of various sizes and many of these are visible on the seabed with their carriages, all of which have been found with the two wheeled type (Eriksson and Rönnby 2017, p. 102). The *Mars* was essentially a brand-new warship when lost and had been issued with the pinnacle of cast bronze weaponry. Unlike the *Mary Rose*, the *Mars* was built when the use of heavy ordnance was already well established on warships, affording it the advantage that it could be designed around the guns. The carriages for these guns, however, were not a worthy match and would have limited the gun's capabilities at sea, as well as the *Mars'* overall fighting potential. This is evident from the lack of gunports at the aft ends of the port and starboard sides of the main gundeck, a result of the long barrel stern chasers mounted on two wheeled carriages, which required a lot of deck space to recoil and reload (Eriksson and Rönnby 2017, pp. 103–04). The effects of using the two wheeled carriage was twofold: first, it reduced broadside capability as gunbays were omitted on both stern quarters and possibly the bow quarters and, second, it hindered the crews ability to reload the guns quickly and within the safety of the ship. Thus, after firing a single salvo from one side the *Mars* would have to turn away from the enemy to reload or come alongside the opposing ship with the intention to finish the battle by boarding. This was very much the traditional tactic but not a tactic that made best use of the most powerful guns on the ship.

The poor performance of guns mounted on two wheeled carriages is particularly obvious from the archaeological evidence from all the known Spanish Armada wrecks, which, before their wrecking, had several engagements with the English navy, most noticeably at the battle of Gravelines. The sites have revealed significant assemblages of un-used shot for all calibres but especially the larger calibres belonging to guns of hull smashing capabilities (Martin and Parker 1988, p. 199), demonstrating a lack of fire from the Spanish ship's great guns. This was in contrast to the English with their fast manoeuvrable 'race-built galleons' with powerful broadsides of heavy guns mounted on four wheeled carriages, which were reported to have peppered the Spanish fleet with continuous close-range bombardments (Martin and Parker 1988, p. 201) resulting in them running out of ammunition (Wilson 2014, p. 141).

Although the *Mary Rose*'s muzzle loading guns were fitted with the better-suited four wheeled carriage, the limited space and lengths of the loading equipment would have made it challenging to bring the guns fully inboard to load within the safety of the hull. To achieve this the guns would have had to be brought back and either angled diagonally forward or astern, or brought in over the hatchways (Hildred 2011, p. 900). This would not have been a rapid exercise. Alternatively, the guns could be brought partially back and loaded by passing the sponges and rammers partly out the gunport. It is also worth noting that although the four wheeled carriages on board the *Mary Rose* were a significant improvement and better suited than the two wheeled, there was considerable room for improvement. First, there are three types (Hildred 2011, p. 44), so there is a lack of uniformity in their design, complicating maintenance, especially if repairs would have to have been made quickly. Second, and most noticeable on two of the main gundeck guns (demi-cannon **81A3000** and culverin **81A1423**), the carriages extend noticeably out from the breech end, much further than needed, especially with culverin **81A1423** (Figure 2.5) (Hildred 2011, p. 26), suggesting the carriages were originally made for longer guns.

Figure 2.5: Examples of oversized carriages. The top image is demi-cannon **81A3000** and the bottom image is culverin **81A1423** (Photos by author).

If these carriages were more compact to suit the size of the gun, like the carriage for cannon **81A3003** (Figure 2.6) then there would have been more deck space for the guns to recoil and for the crew to load. The development of the gun carriage was key to improving the performance of the gun and the fighting capabilities of the ship and will be a focus of this research in forthcoming chapters.

Figure 2.6: The carriage for cannon **81A3003** is more compact and suits the length of the gun (photo by author).

The *Mary Rose* had the advantage that, unlike the *Mars,* she was equipped with many more breech loading artillery, which ranged from hull smashing to anti-personal capabilities. According to the Anthony Roll these guns included 12 port pieces, two slings, three demi-slings, one quarter-sling, six fowlers, 30 bases, two top pieces and 20 hailshot pieces (Knighton and Loades 2000, p. 43, Hildred 2011, p. 131). The archaeological evidence has so far accounted for eight port pieces, four slings, four fowlers and 15 bases (Hildred 2011). As mentioned above these breech loaders could be reloaded relatively rapidly and within the safety of the hull.

The starboard side of the main gundeck of the *Mary Rose* was almost complete except for the forward quarter, which may or may not have housed an additional gun. From the seven surviving gunbays on the starboard side of the main deck, six guns survived with their carriages adjacent to their gunports, the seventh and aft most gun was missing but its broken carriage was still present (Rule 1982, p. 153, Hildred 2011). The gun's equipment and ammunition, both ready to use and surplus, were found close to each gun and in several storage areas. Together this has provided a rich understanding of how the guns were supplied and operated during the heat of battle.

As mentioned previously, four of the main deck guns were the breech loading port pieces. These were medium ranged guns and, when loaded with stone round shot, were capable of smashing through the hull of a ship. This type of weapon may have been dated but it was far from obsolete and it gave the *Mary Rose* the ability to fire repeat salvos without having to disengage to reload. This would become the standard practice from the mid-17th century onwards. As the distance reduced, the short-ranged bronze cannon could come into range followed by the smaller wrought iron pieces on the decks above, also with the ability of repetitive fire (Hildred 2011, p. 900). Whether this was how the *Mary Rose* was fought we may never know, but she had the potential to be used in this manner. The combination of four wheeled carriages for the muzzle loading bronze guns, used alongside significant numbers of heavy and light breech loading wrought iron guns, made the *Mary Rose* a formidable ship of her time and more advanced regarding gun technology and operation than other European naval rivals of the day and near future.

In terms of gun technology, the larger wrought iron guns were reaching the end of their time. Despite their capability for rapid reload and being relatively inexpensive to produce, they were considerably more dangerous to use because of the crude method of securing the chamber in the breech, and they lacked the reliability of cast muzzle loaders. The cast muzzle loading guns were the future, and ship design and equipment had to adapt to make best use of these guns. It is because of the *Mary Rose* and other ships like her in Henry VIII's fleet, that the English grasped quicker than most what was required to make a successful warship. The large cast muzzle loading guns on four wheeled carriages were the ultimate weapon for sea service, which ultimately led to ship design changing to suit the housing of heavy ordnance lower down. Essentially this led to lower and sleeker hull designs, which allowed vessels to manoeuvre into position better and provide a more stable gun platform with greater space across the gundecks to operate the guns.

2.5.1.3 Organisation of the *Mary Rose* gunnery system

With the variety of weapons on board comes the need for an organised supply chain of powder, shot and spare equipment to keep the guns operational throughout a battle. The *Mary Rose* provides the earliest evidence of the organisation and supply of the gunnery system on board ship. Through the comparison with other shipwrecks throughout the period, it is possible to identify both changes to improve the efficiency and maintenance of the gunnery system as well as old habits of organising stores that are kept and can be directly linked back to the *Mary Rose.*

Except for the powder there were several areas identified on the *Mary Rose* dedicated to the storage of shot and spare equipment. The evidence of the storage and containerisation of powder was sparse, having not survived 500 years of submergence well. The Antony Roll listed two lasts (24 barrels) of serpentine powder and three barrels of corn powder to supply all the guns on board (Knighton and Loades 2000, p. 43, Hildred 2011, p. 423), the bulk of which must have been stored in a dry secure place on either the orlop or in the hold, away from the galley amidships.

Shot

As well as varying sizes of projectile to match the calibre of guns there were different types and even materials used. Each type had a specific purpose to be used at different ranges and with specific tactics. The *Mary Rose* was therefore equipped to compete at all ranges. The following will focus on the projectiles fired from the larger artillery rather than smaller anti-personnel weapons. The round shot was the projectile of choice at all ranges to smash holes through the hull of the opposing ship; at medium to short ranges the cross bar (a round shot with a metal spike) and hemisphere shot (two hemispheres linked by chain or extendable bar) could be used to cut down rigging; and at short range a variety of canister shot filled with stone and metal objects were used to spray the enemy decks to clear them of their crew and soldiers. Some materials were specific to particular types of gun, such as the Kentish ragstone round shot, which was particular to the port pieces on the main deck and fowlers on the upper deck; cast iron round shot, which were for the bronze guns and wrought iron slings; the cross bar shot, which were solely fired from the bronze guns; and canister shot for the wrought iron pieces (Hildred 2011, pp. 310–70).

The bulk of shot was cast iron round shot followed by the stone shot, with the greatest number being for the medium ranged port pieces (Hildred 2011, pp. 311–14). The majority were stored in specific areas on the main gundeck close to access points to other decks, which would have enabled easy access and retrieval of shot to all areas (Hildred 2011, p. 312). Much of the stone shot was unfinished, which meant if a particular size was used up there was shot available that could be finished to that specific calibre. There were also smaller amounts of various types of shot found around the gun stations intended for immediate use and specific purposes. A good example of this is the canister shot close by the port piece in M8 on the main deck, at the ready to offer support prior the final action of boarding the ship (Hildred 2011, p. 903). Excluding the canister shot the evidence of the containerisation of shot was particularly slender. It consists of mobile containerisation of shot derived from two concretions containing shot, which were flanked by pieces of wood, interpreted as the remains of a possible box, and three small solid lead shot found in a basket also containing a rammer head (Hildred 2011, p. 313). From this evidence it is possible to surmise that small amounts of shot for immediate use with individual guns were kept in boxes or baskets close by. It is difficult to imagine that there was nothing to contain the shot, especially the round shot, but there has been no evidence as conclusive as the shot holders found on 18th and 19th century gundecks and described in chapters seven and eight.

In one specific section of the hull adjacent to the culverin on the upper deck were 14 round shot for that gun. They were stashed between the frames next to the gunport and held in place by a plank nailed to the outside face of the frames (Hildred 2011, p. 312). This was the only example of the containment of a large amount of shot for a specific gun, which could possibly be evidence of the practical experience of the individual gunner in charge of that culverin. The location of loose shot in both areas of storage and around the guns suggest the containment of shot was generally poor on the *Mary Rose* and this is an area where improvements can be tracked.

The above shows there was clear organisation of shot but there was still scope for confusion. There were mixed calibres of shot stored together and there was no evidence of containment within the main areas of shot. This demonstrates the importance of shot gauges and explains the nine that were found (Hildred 2011, p. 401). The analysis of these gauges has shown that there must have been several more as there are several sizes of shot that do not match the gauges (Hildred 2011, pp. 406–07). The main stores of shot were all on the main gundeck, which was convenient for quick access, but these stores would have taken up valuable space and the lack of containment was potentially dangerous to the crew with the pitching and rolling of the ship. The amount of shot would have been a considerable weight and its location and potential mobility would not have been beneficial to the overall stability of the ship. The storage and distribution are areas where obvious changes had to occur and will become apparent in later chapters.

Like the storage of culverin shot there are many other examples of individuality on board the *Mary Rose*, the linstocks, another example, owned by the gunner of a specific gun and used to hold the slow-match for igniting the powder in the touch holes, are all individually designed with ornate carvings of dragon heads or clenched fist (Hildred 2011, p. 487). They served a specific function but were also symbolic to the individual gunner; a kind of badge of office (Adams and Rönnby 2020, p. 185). The idea of the gunner's ownership of their linstocks is reinforced by the fact that linstocks are not listed in Tudor inventories (Hildred 1997, p. 57). It will become apparent as this study progresses through the period that as the ship and naval warfare develops, equipment, tools and the space on-board becomes increasingly marinized to make working the ship and the guns as efficient and effective as possible. There is, therefore, less room for individuality and the operation of the ship and the guns becomes a series of routines and actions that crew repeat daily. Naval life essentially becomes increasingly institutionalised (Adams and Rönnby 2020, p. 185).

Equipment

This section will focus on the equipment regarding the organisation of the gunnery system, as opposed to the operation of the guns. As with all eras of gunnery the demands of operating the guns led to the inevitable wear and tear of equipment; the *Mary Rose* was no different to any other warship of the time or after. What ones sees with the evidence from the *Mary Rose* is the origins of particular habits that are still visible on ships at the end of the period of this study. A prime example of this is the gunner's store(s). On board the *Mary Rose* there were two obvious stores for spare gun equipment and accessories, the majority of which were the heavier and bulkier items, such as gun carriage axles and wheels or consumable types, such as tampions. There were smaller numbers of other equipment kept here too, such as spare rammers. These were stowed in the forward most sections of the orlop and hold, one directly beneath the other (Hildred 2011, p. 105). These areas were below the waterline and therefore generally safe from potential damage from gunfire. Down on these decks they were out of the way and therefore not an obstruction on the busier gundecks.

As well as clearly defined stores for the spare gun carriage components, other stores or spare equipment were stowed in less defined areas or mixed in with other stores. Examples of this were two rammers and five ladles found in M6 (location of gunbay for bronze cannon **81A3003** on main deck) among the shot and the gun (Hildred 2011, p. 903). If indeed this was a store for spare equipment as well as the shot this clutter of objects, along with the aft side of the barber surgeons cabin, would have restricted the space in which the gun and gun crew could move. This clutter of equipment, stores and munitions was not unique to this gunbay. Much of this patterning may have been a result of the ship violently healing over onto its starboard side during the wrecking, causing objects to fall and accumulate on the sides by the gunbays. For the objects to be there, however, they had to be on the gundeck to begin with. The density of the objects suggests that the gundecks were a cluttered place and that there was poor containment and stowage of surplus equipment. As the navy develops through the period of study, the organisation of stores clearly improves. Cabins and surplus stores are removed from the gundecks and are concentrated in areas of the hold and orlop. This declutters the gundecks allowing greater space for the operation of the guns.

2.5.2 *Existing evidence of working the guns*

Over one hundred years separates the *Mary Rose* from the next major warship and the first main case study of this research, the second-rate ship of the line, the *London.* In that time significant changes occurred in ship design, fighting tactics and gunnery. This period really deserves its own results chapter, as it would cover the transition from the large carracks to the smaller but more dynamic ‘Elizabethan’ or ‘race-built galleons’, through to the early ship of the line, as we see with the *London*. There is, however, a large void in the archaeological record, certainly from an English perspective, with the exception of the wrecks of the much smaller warships of Elizabethan wreck off Alderney (Monaghan and Bound 2001) and the Cromwellian wreck off Duart Point, Mull, Scotland (Martin 2017). Until new archaeological evidence comes to light one should except that there will be gaps in our understanding of the late 16th to mid-17th century English naval gunnery.

The physical evidence for working the guns comes predominantly from the carriages and the equipment used to load, manoeuvre and fire them. Although gun sites or even Royal Navy sites are not particularly rare, finding a gun with its associated carriage is, and finding one with carriage and associated gun tackle, furniture and equipment even more so. The latter normally occurs when the structure of the ship survives too.

There have been a handful of gun and carriage recoveries from Royal Navy sites since the *Mary Rose,* extending across the period of study. Fortunately, the investigative work on several of these examples, including those from the *Mary Rose,* have been published. Examples come from the investigation of port pieces and wrought iron guns (Smith 1993), ordnance and associated artefacts from a 16th century wreck off Alderney (McElvogue 1999, Monaghan and Bound 2001), a minion drake and carriage from the Cromwellian wreck off Duart Point (Martin 2004, 2017), a carriage from the 17th century wreck of the *London* (Pascoe 2017a), and a carriage and gun from the early 18th century wreck of the *Stirling Castle* (McElvogue 2008). An important point that needs to be recognised is that the Cromwellian warship and the Elizabethan wreck were not apex fighting ships like the majority of the ships in this study but were relatively small warships with different operational capabilities to that of larger warships. The ways in which the ship and armaments were deployed differ to the larger warships. As such, the size of the vessels and their purpose for being must also be considered when studying and understanding the evidence on gunnery from shipwrecks.

In addition to shipwreck finds there is a 17th century ship's carriage at Windsor Castle (Smith 2001). Original carriages such as this are rarely found on land as old carriages would have been broken up, discarded or recycled. In fact, evidence of recycling was discovered from a terrestrial dig at the Woolwich Arsenal (Prudames 2004). Here over forty pieces of broken carriages were found in the foundations of a building. Although the Windsor Castle and Woolwich Arsenal examples are disconnected from their original context, their design and construction can provide useful evidence on design and how they were mounted and secured on board ship.

Due to the rarity of the recovery of intact and well-preserved carriages from shipwrecks there are several years separating each find. There has therefore not been the opportunity for previous researchers to compare all of these examples together. This research will study these carriages as a collective to reveal the changes in design and construction over time. In many cases these changes will be uniform and quite deliberate following a particular design pattern. However, sometimes it is possible to identify evidence of specific alterations that will be unique to that carriage and the gun it mounted. Alterations can occur due to a need for repair or lack of uniformity in the guns or construction of the vessel. This not only reveals vital evidence on how particular guns were mounted, operated and secured but also provides critical evidence for understanding the skill and behaviour of those people adapting and using the guns. From a cultural perspective, it not only helps the researcher understand the behaviour on board ship but also the wider culture of the naval administration and management. Subsequently it will be possible to examine the subject of standardisation and the effects this had on the efficiency of the Navy.

With the exception of the *Mary Rose* (Hildred 2011) and to a lesser extent the *Invincible* (Bingeman 2010), there are very few publications that include a detailed study of the gun accessories, which were essential in the gun's use. One reason for this is that they do not survive. The accessories in use would have been in close proximity to the gun, with the majority of these being made of wood and therefore susceptible to floating away when the ship sinks and breaks up. Where the gun's accessories have been found is where the ship has rapidly become buried, trapping and preserving such objects. The most recent excavations on the *London,* the *Hazardous* and the *Invincible* have yielded significant assemblages of gun equipment. These include equipment from gundecks as well as spares found in storerooms. In addition, a collection of material from the wreck of the 2nd rate *St George* (1811), held at the Strandingsmuseum in Denmark, which includes lots of gun equipment, has been assessed. The study of these will fill existing gaps in knowledge and greatly enhance the understanding of the tools needed to work the guns. Their study will identify changes in style and form and part of this research will determine whether these were merely stylistic or functional.

2.5.3 *Existing evidence of organisation of the gunnery system*

Representing the mid-18th century there is the site of HMS *Invincible*, wrecked in 1758 in the Eastern Solent. Its leading investigator between 1980 and 2010, Commander John Bingeman, has published the sites' first phase of investigations in *'The First HMS Invincible Her Excavation (1980-1991)'* (Bingeman 2010). The *Invincible* represents the most extensive and best-preserved mid-18th century warship so far found in the UK. The wrecking event was not a violent one and the ship actually remained partly above water for a several months (Lavery 1988, p. 104). In that time the ship's guns and other valuable equipment was saved from the ship. Despite the salvage of the guns and other stores, the excavations in the 1980s and early 90s recovered hundreds of well-preserved artefacts, many of which were related to working the ship's guns. These artefacts included gunner's stores and thus spare equipment to keep the weaponry system working and maintained, barrels of gun powder and cartridge cases to keep the guns supplied with propellent. The intact nature of one side of the hull preserved the majority of these artefacts in or close to their original place on board the ship. Bingeman's publications have provided a detailed study of the artefacts and, if used alongside the unpublished annual site reports and diver's logs, provides the relationship between the objects and where they were stored.

In 2010 the author of this thesis was handed the responsibility of the *Invincible* site by Historic England, with the blessing of John Bingeman. In 2017 this led to the author working with Professor David Parham of Bournemouth University, alongside the Maritime Archaeology Sea Trust (MAST) and the National Museum of the Royal Navy (NMRN), on a three-year excavation of the site. These excavations have led to further discoveries of gun related material and vital information relating to their organisation and stowage on board the ship. This new information will be vital in filling the missing gaps and, together with the previous work by Bingeman, provide the evidence on how the weapon system was kept supplied and how those supplies were organised and distributed on-board. This is critical information, which is so often lacking due to poor survival of the ship or lack of fully intrusive and investigative archaeology of shipwreck sites. The study of the distribution, storage and organisation of stores and supplies on board the *Invincible* will be compared to that of the *Mary Rose* to see how the supply system has changed and developed. However, there is a huge gulf in the design and layout of the two ships. Unfortunately, the *Mary Rose* and the *Invincible* are rare examples in terms of extent of survival of the ship and also complete excavation of the remains. Furthermore, the available data with which to try and understand the supply and storage system during the intervening period between the two sites is less complete, due to a combination of poorer survival of archaeological remains and/or less extensive investigations.

2.5.4 *Existing evidence for securing the guns when not in use.*

The third aim of this research is to study the archaeological evidence for securing the guns when not being used in action. The great guns along with their carriages were extremely heavy objects weighing between a ton and 2.5 ton, depending on their calibre. For the safety of the crew and the ship, they would need to be secured to the inside of the hull at all times. Failure to do so would lead to potential fatalities of the crew, damage to structure of the hull or even loss of the ship (Harland 1984, p. 209). The gun's security on board was therefore paramount and a great responsibility that fell on the master gunner (Cole 2009a, p. 287). There are a number of technical publications that examine the various ways a gun would be secured for either action, transit or bad weather. Securing extremely heavy objects such as the guns was quite a complicated process involving an array of blocks and tackle, as well as the breeching ropes. In addition, rope lashings were used to lash the barrel and muzzle of the gun tightly to the inside of the hull. The lashing were essential in bad weather as they restricted any movement of the guns (Harland 1984, p. 210, Lavery 1987, p. 141).

The archaeological evidence for securing the guns can be found on either the inside of the hull, particularly around the structure of the gunports in the form of fixtures and fittings, and on the guns and carriages themselves in the form of gun tackles, breechings and lashings. The earliest published evidence of the latter comes from the wreck of a small Elizabethan naval auxiliary vessel found off the island of Alderney, in the Channel Islands (Monaghan, J. and Bound 2001, p. 53). A gun was recovered with fragments of both cheeks of its carriage, muzzle lashings, breeching and contents of barrel surviving. The fragments of the carriage revealed a typical sea service carriage, very similar in design to those found on later sites, such as the Duart Point wreck, the *London* and the *Stirling Castle.* Following de-concretion of the gun and separation from the carriage, vital clues to how it was secured to the inside of the hull were revealed, despite nothing of the inside of the hull surviving.

The barrel was resting on the rearmost iron transverse bolt and elevated at an angle of 8° to the bed, demonstrating it was at its maximum elevation. A triple lashing of hawser-laid rope was found around the muzzle end of the gun and a cable-laid rope secured around the button. Removal of the tampion and excavation of the barrel revealed it was dry and that the gun was loaded with wadding, an iron round shot and powder charge. The touch hole was sealed with a wooden plug (Monaghan and Bound 2001, p. 53). The evidence from the recovered gun and associated equipment alone identified that it must have been secured to the inside of the hull, loaded and in the elevated position, most likely with the muzzle fastened above the port with the triple lashing and the breeching rope securing the gun from the rear.

Later evidence for gun security and specifically from the inside of the hull, comes from the site of HMS *Colossus*, a 74-gunship wrecked on the Isles of Scilly in 1798 (Camidge 2012). Excavations in 2012 uncovered and recorded the surviving structures of one of the main gundeck gunports. The gun was missing, believed to have exited through the gunport during the wrecking. However, gun tackle, including the double blocks, were found inside the gunport. These were part of the tackle used to manoeuvre the gun forward. Most interesting was a worn and abraded semi-circular moulding above the upper sill of the gunport (Camidge 2012, p. 38); exactly the evidence for how the guns were secured when not in use. The abrasion shows where the muzzle of the gun rubbed up against the upper sill, because the practice for securing the guns when not in operation or preparing for bad weather was to lash the muzzle of the guns tightly above the port. This was carried out by removing the elevating quoin, which was supporting the breech, pulling the gun forward, so the muzzle was against the top of the gunport sill, and lashing the muzzle. There were two iron ring bolts above the sill to thread the lashings through.

Over two hundred years separate the wrecks of the Alderney wreck and *Colossus* but the evidence relating to gun security provides another example of an aspect of the gunnery system that remained remarkably unchanged. There were of course other methods for securing the guns, evidence of which is provided by other sites and will be discussed in chapters six and eight.

2.6 Conclusion

The disciplines of history and archaeology are both integral to this research. Historical sources provide detail and description of the many facets of the gunnery system, demonstrating what existed at a particular time, or what should have existed at that time. The archaeology identifies what was actually there, and in use, and the details found on the objects and their context within the ship provide unique insights into the practices and skills of those on board. This chapter has not only used both disciplines to contextualise this research, but through doing so also identifies where a lack of archaeological information exists. The review of the archaeological record has identified that, excluding the *Mary Rose,* the existing evidence from shipwreck sites is fragmentary or incomplete and this is either through poor survival of material or less intrusive investigations and the gathering of gunnery related material. As such there are many gaps in knowledge relating to every facet of the naval gunnery system throughout the study period. The gaps in knowledges are as follows:

- Gun equipment and accessories, which are essential for understanding how the guns were operated, secured and maintained;
- Structures, fixtures and fittings from the gundecks, also essential for understanding how the guns were operated;
- How gundecks were equipped with ready-to-use shot;
- How surplus equipment, ammunition and powder was organised and stored around the ship;
- How powder was contained and transported from magazine to gundecks;
- How the gunnery system was generally maintained.

The results from the recent investigations from the *London, Hazardous,* and *Invincible*, alongside the analysis of existing material and records from the *Colossus* and *St George* will bridge these gaps through the introduction of significant and original archaeological research.

As a key maritime archaeological investigation, the *Mary Rose* was reviewed here in detail as this is the one archaeological site that has been intensely studied; all facets of its gunnery system have been analysed. It also sits as a chronological marker for this work, effectively marking the origins of the Navy proper. With the *Mary Rose* as a foundation, the structure of the case studies that form this thesis follow this body of work, looking at organisation, maintenance and operation of the naval gunnery system and its evolution through time.

Chapter 3 Case Study Selection

3.1 INTRODUCTION

Five main case studies, the *London*, the *Hazardous,* the *Invincible,* the *Colossus* and the *St George,* have been chosen for this study. This chapter explains the rationale behind their selection (section 3.2) followed by introducing each case study with a brief historical background of the period and of the ship, their wrecking event, salvage history, site location, discovery and description in sections 3.3-3.6. This will provide context for the archaeological aims of this research.

3.2 CASE STUDY RATIONALE

The choice of case studies was determined by two key, interconnecting factors: first, the sites needed to be relevant to the timeframe and questions being asked. Second, these wrecks needed both quality and quantity of available data with which to address these questions. A review of the current literature indicated the incomplete and fragmentary nature of the existing archaeological record with many gaps in the understanding of all facets of the naval gunnery system, throughout the whole study period, and which are summarised in section 2.6. Due to the richness of the archaeological record emerging from these cast studies they will work towards filling many of those gaps in knowledge. Each of these sites represent a 'time capsule' or a 'fine grained' assemblage (Binford 1978, pp. 19–20) of their period. Adams describes these terms as like a high-resolution image of past activity, where well-preserved objects survive in their context of use (Adams 2013, p. 20). This leads to an understanding of the relationships between individual objects, between assemblages of objects and between these assemblages and the structures within which they were stored and used (Adams 2013, p. 20). In other words, well-preserved wreck assemblages make the connection between material culture and behaviour more achievable (Gibbins 1990, p. 387). This is the type of detailed information needed to understand exactly how the people on board these vessels operated, maintained and organised the naval gunnery system.

The case studies were chosen because they are warships classified as *Class 1* shipwreck sites, following Muckelroy's wreck classification (Muckelroy 1978, p. 165). The distinctions of a *'Class* 1' wreck are as follows: structural remains are extensive; organic remains are many; other objects are many; and distribution is coherent (Muckelroy 1978, p. 165). All these sites, therefore, have the potential to reveal a significant understanding of the naval gunnery system, from organisation to maintenance and operation of the guns.

To fulfil the potential of these sites and gain the maximum information needed to answer the research aims, they require micro-scale or intra-site analysis techniques to be able to interpret the wreck and artefact assemblages to the level required (Ortiz-Vazquez 2018). This has been made possible through excavation or, in some cases, natural exposure, enabling access to well-preserved areas of the wrecks where artefact assemblages could be recorded in detail within their space in the ship. However, the level of investigation ranges between the case studies from full excavation to partial or strategic. For example, most archaeological investigations are not as comprehensive, or wreck sites as intact and well-preserved, as the *Mary Rose* or *Invincible*. As such, there is not always the opportunity to reveal a complete understanding of a site and, with regard to this research, the entire naval gunnery system of each wreck.

There are, however, many other known wrecks of the Royal Navy that represent similar periods to each of the five main case studies. The information from these other sites, albeit fragmentary or incomplete, can often fill some of the gaps in knowledge and understanding, or provide comparable evidence relevant to another site or sites. Examples are the wrecks of the Cromwellian shipwreck off Duart Point, Mull (*c.*1650s) and the *Stirling Castle* (1679-1703), which provide comparable evidence for two of the main case studies: the *London* and the *Hazardous*. In both instances fairly complete gun carriages with their guns were recovered from the wrecks (McElvogue 2008, Martin 2017). The carriages were similar in type and design, but by no means identical to, the examples found on the *London* and the *Hazardous*. Each assemblage provides unique information and, studied as a collection rather than separately, provide a more complete interpretation on how the guns were mounted, operated and altered during these periods.

During the data collection phase of this research, numerous gunnery artefacts and hull remains of shipwrecks were studied for technological and morphological purposes. What is important to emphasise, however, is that whilst this descriptive information is important from a practical perspective, they can also tell us about the people that made and used them. The objects through time can change in style and form as well as with respect to where they were used and stored. Through analysing the objects and their spatial distribution, this research will attempt to understand why these changes occurred and what difference they made to the gunnery system and the people that operated the gunnery system. The study of these objects and where they came from helps determine the social order, culture and behaviour of shipboard societies (Rönnby 2013a, p. 11). As such, whilst the description of equipment remains a crucial exercise, this research will develop a more expansive research agenda to extend beyond technology, form and function (Adams 2013, p. 50). Following Adams' example, the case studies below will work outwards from the gun's equipment and organisation within the ship towards explanations that involve the technological developments in a cultural context (Adams 2013, p. 51). In other words each case study is representative of a significant period in the development of naval gunnery through the timeframe in question and the archaeological evidence will be analysed to identify technological innovation and associated social changes (Adams and Rönnby 2013a, p. 23, Ortiz-Vazquez 2018, p. 2).

As previously mentioned, the naval gunnery system is made up of an array of weapons, equipment, tools, propellants and projectiles and these are represented as artefacts in the archaeological record. This study is therefore heavily based on artefact analysis from each of the main case studies, with an approach to obtain more cognitive information from the artefacts (Djindjian 2000, p. 41). There are two types of information gained from artefacts recovered from a shipwreck or any other archaeological site. First, '*intrinsic information'* is knowledge gained from the actual artefact such as size, morphology, physical and chemical characteristics. Second, *'extrinsic information'* is the information recorded from the context of the artefact such as stratigraphy or the spatial locality within the shipwreck (Djindjian 2000, p. 43). Where possible this research has attempted to understand and interpret the correlations between the intrinsic and extrinsic information, which initiated a cognitive process increasing the knowledge of the artefact system (Djindjian 2000, p. 43).

The type of intrinsic information this research has tried to gain from the artefacts found within the main case studies is as follows:

- Size;
- Morphology;
- Physical and chemical characteristics of the raw material;

- Manufacturing technology;
- Manufacturing quality;
- Function;
- Use;
- Social meaning;
- Individual signature.

Extracting this information will reveal the people behind the artefacts, from the makers to the operators of the naval gunnery system. Combining this with the extrinsic information gleaned from the organisation and location of gunnery artefacts from the gundecks and storerooms, this research will go beyond understanding merely typology and function, but instead imbue the artefacts with a social and cultural meaning (Djindjian 2000, p. 43, Rönnby 2013a, p. 9). For example, by understanding the distribution of groups of artefacts, such as spare gun furniture, this research will identify how and where equipment was organised. The comparison with other wreck assemblages will elucidate levels of organisation and how these differ from ship to ship. The evidence of levels of organisation will potentially determine the attitudes and behaviours of the ship's crew and identify attributes of professionalism and discipline in the Royal Navy, and whether this changes through the study period.

The archaeology from the case studies is the primary focus, however, the history of the ships, including their wrecking events, salvage history and subsequent site formation processes have all had an impact on this. Understanding the life cycle of the vessel from a working ship all the way through to the current condition of the wreck will help provide a more accurate interpretation of the archaeological remains. In some cases, a detailed history of the ship survives that includes logs, journals, dockyard ledgers and Admiralty letters, all of which can provide a window into life on board. Consequently, when studied alongside the physical evidence, it is possible to develop a more rounded and informed interpretation of the relationships between the ship, its material culture, and the crew (Adams 2013, p. 48, Rönnby 2013a, pp. 16–18). Through this it is possible to create working hypotheses related to the changing behaviours and habits of the people on board, specific to the organisation, maintenance and operation of the guns.

The challenge when dealing with a limited data set, however, is determining whether the evidence from a single ship is representative of all ships across the fleet. This is because ships were commanded by individuals, not all of whom will have commanded the ship in the same way. Those individuals, however, were part of a social system, meaning that they generally followed the standards and social norms of the day. To help mitigate this obstacle, then, it is necessary to have a comprehensive historical understanding of the navy, the naval administration and the maritime needs of the nation across the whole-time frame, which each case study provides.

In summary, each case study necessarily provides evidence of the following:

- Functioned as a warship during loss;
- Typology of gunnery equipment;
- Morphological changes to the equipment;
- Context within the ship/wreck, as the relationship between the object and where it was found would determine:
    - Use;
    - Maintenance;
    - Organisation;
    - Behaviours and routines of the crew.

Where there were gaps in the evidence within a main case study, data from other sites from the period of the main case study have been used.

3.3 THE *LONDON* (1656 – 1665)

The *London* is the main case study of chapter five and has been chosen to represent the development of naval gunnery during the third quarter of the 17th century.

3.3.1 *Historical background*

The *London* was a second-rate ship of the line constructed at the Royal Dockyard at Chatham under the supervision of the Master Shipwright, John Taylor (Figure 3.1). It was one of four second-rates ordered by the Lord Protectorate, Oliver Cromwell, on the 3rd July 1654 (Fox

1980, p. 69, 2011, p. 19, Winfield 2009, p. 26). This was a programme in response of the recently ended First Anglo-Dutch war and the need to strengthen the Navy with new ships, due to the threat from Spain, France and Holland. Despite the need there was insufficient funds to build all the proposed ships with the *London* and *Dunbar* the only two launched on time in 1656 (Fox 2011, p. 19). The third ship, the *Richard,* was launched in 1658 as a first-rate, the fourth ship never materialised.

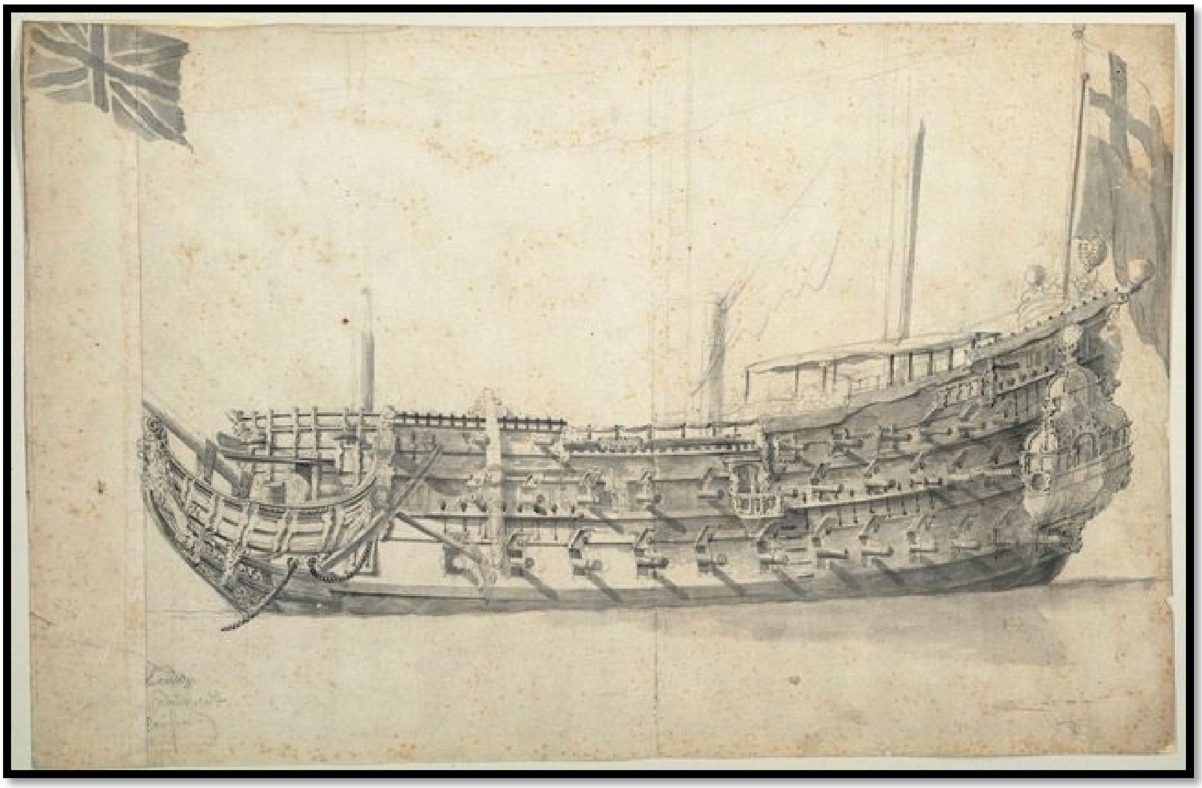

Figure 3.1: A contemporary drawing of the *London* by the Dutch artist William van der Weld (Image PAG6182 © of the NMM, Greenwich, London).

Relevant to this research is the *London's* service career. Basic knowledge of this will not only contribute to a better understanding of how practiced the Officers and crews of the *London* were in the use and maintenance of the gunnery system, but will also provide a general understanding of how active the Royal Navy was at this time.

The *London's* first commission came a year after her launch in June 1657 and she served until her loss on the 7th March 1665 (Winfield 2009, p. 26). The *London*, therefore, missed out on the tests of the first two Anglo-Dutch wars. Despite this lack of battle honours the *London* was still very active during her service career, conducting important duties, mainly as a flagship. These were extremely tense times for England with hostilities with Spain and a second trade war with Holland inevitable. The pressures brought on by war, or the threats of war, generally accelerated advances in technology and the adoption of innovative ideas or tactics.

The First Anglo-Dutch war, for example, witnessed the start of a transition in battle tactics from the traditional Elizabethan approach of attacking in squadrons to the general adoption of the line of battle, which involved the whole fleet joining the action together and which would become the ideal for the following 150 years (Rodger 1996, p. 317). The success of the latter would depend on the continuous fire of guns on one side, known as a broadside, and the ability of rapid reloading of those guns, an art that would not be mastered until decades later with the increase in numbers of gun crews and greater efficiency of supplying and operating the guns (Rodger 1996, p. 317).

The English generally had larger ships that could carry heavier guns than the Dutch. These attributes were advantageous to the line of battle tactics as the English were able to come within range with their guns yet out of range of most of the Dutch guns (Padfield 1973, p. 74). Large ships that could carry heavier guns suited the line of battle tactics and their proven success in the first war ultimately led to the building of bigger ships like the *London*. The *London*, therefore, represents a front-line ship at the beginning of a key period in the development of naval tactics and operation of the guns.

The *London's* first commission involved deployment in The Downs, as well as patrolling the English Channel, in support of an Anglo-French land campaign against the Spanish and Royalists in Flanders. During that time, the *London* was trialling the performance of nine iron home-bored cannon of seven, produced by the gun founder Henry Quintyn. These were the largest gun types and were carried on board first and second-rates. At this time there were difficulties casting guns of this size in iron and bronze was unaffordable, so Quintyn's guns were an attempt to produce the more affordable cast iron variety (Fox 2011, p. 24). After six months service on the *London* they were proven to be muzzle heavy causing violent recoils, typical of home-bored weapons. These trials were one example that shows this was a period of experimentation, trying to seek out what were the best guns for use on board ships. It also demonstrates that live fire gunnery was being practiced on board the *London* and that there was a good understanding from those aboard of the requirements of a good naval gun. It would appear, however, that despite their poor performance, the Ordnance Office kept these guns and that they went on to have a considerable history of redeployment; records from the second-rates *Royal Katherine* and *Royal Oak* identify that they were in use during the Second Anglo-Dutch War 1664-67 (Fox 2011, p. 25). This is an example of how demand often outweighed production, resulting in ships issued with unsuitable guns because there was a shortage of guns to arm the whole fleet with the preferred standard. This is a trend that continued well into the last quarter of the century, evident from the arming of the 30 great ships of the 1677 shipbuilding programme (Lavery 1987, p. 116).

During the winters of 1657 and 1658 the *London* remained at sea, commissioned as a flagship in the winter guard based in The Downs, off the east Kent coast, and then part of a blockade during the siege of Dunkirk. This ended after the fall of Dunkirk in June 1658 and the *London* returned to Chatham (Fox 2011, p. 24). As a flagship to Admiral Richard Steyner the *London* headed to the Baltic in 1659 to attempt to mediate in the conflict between Sweden and Denmark and, in doing so, secure English access to that sea. By the autumn the *London* had returned to England and was laid up in ordinary until spring of 1660 when, under the command of Vice Admiral John Lawson, the ship formed part of a fleet that brought Charles II to his restoration: the *London* supplied transportation for the Kings brother, James, Duke of York. The *London* continued to serve throughout the winter period and finally returned to port in April 1661 to be laid off (Fox 2011, p. 25).

The *London* spent the next three years in ordinary and did not return to service until June 1664, then under the flag of Edward Montagu, Earl of Sandwich. The ship was originally assigned a mix of bronze and iron guns, to match the new establishment. However, Samuel Pepys, clerk of the act of the navy board and cousin to Montagu, insisted as a flagship that the *London* must have all bronze guns. The number of guns was increased to 74, with the extra guns located at the empty chase ports, giving an all-round arc of fire more suited to the old Elizabethan tactics than the current adoption of line of battle, which suited continuous fire from the broadside. This demonstrated how the naval administration had little understanding of the new tactics being deployed by the current crop of commanders (Fox 2011, p. 26). Furthermore, the allocation of an entire battery of bronze guns was exclusively for the prestige of Montagu rather than for firepower. Iron was a cheaper and more available raw material to produce guns with, so, as soon as the casting method was perfected, iron guns quickly replaced bronze as the standard naval artillery. Serviceable bronze guns remained in use and entire batteries of bronze guns were produced into the 18th century only for the finest ships in the fleet. The *Victory* of 1744 and the *Royal George* of 1756 being two examples.

There were issues with allocating bronze guns to the *London* because there were simply not enough bronze guns to match the establishment, so the Ordnance Board supplied what was left in store. This resulted in eight 24-pounders, 16 demi-cannon and two culverins replacing the original assignment of 12 cannon of seven and 14 demi-cannon on the main gundeck. The latter bears considerably less power than the original assignment, demonstrating that aesthetics were more important than performance (Fox 2011, p. 27). The 24-pounder gun was not a standard size in the navy at this time and modern recoveries will identify that several of these were captured foreign guns or older English culverins bored out (Fox 2011, p. 27). The archaeological evidence also demonstrates that this affected the equipment supplied for those guns.

3.3.2 *The wrecking, contemporary and modern salvage*

Before the wrecking is explained, it is necessary to briefly describe the immediate events leading up to the loss of the ship. These play a crucial role in interpreting the evidence found on the seabed, discussed in chapter five.

On the 6th February 1665 following an eight-month commission under the command of Edward Montagu, a change of command from Montagu to Vice- Admiral John Lawson was ordered. A second war with Holland was imminent, so the ship hastily sailed back to Chatham dock from The Downs for routine maintenance and preparation for the new command and operations (Fox 2011, p. 28). On the 20th February the ship entered the dry dock at Chatham and all her guns and gunner's stores were taken out and registered in the Chatham ordnance ledger (TNA WO55/1667). The ledger identifies that the stores were returned to the ship three days later, on the 23rd February. Two days later the *London's* Master Gunner, Gabriel Walters, was given orders to transfer to the *Royal Prince* (TNA WO55/331). It appears, therefore, that he was still on board the *London* to take charge of the gunner's stores on the 23rd. The *London's* new master gunner, Richard Hodges, chosen back in January, would have been on board to take charge of the stores following the departure of Gabriel Walters (TNA ADM106/10). It was his responsibility to ensure powder, shot and gunner's stores were organised, secured and ready when the ship departed on the 7th March.

The wrecking

On the 7th March the *London* left Chatham with 325 of the 450 crew plus an undetermined number of wives and girlfriends and sailed up the Medway into the Thames Estuary. The plan was to travel upstream on the flood tide and pick up the Vice-Admiral Lawson, along with the other officers and remaining crew, at a place known as the Hope. A little distance west of the buoy of the Nore, disaster struck when a catastrophic explosion, most likely from the main powder magazine, caused the ship to blow up with devasting effect (Fox 2011, p. 15). Negligence in the handling of the powder was a probable cause and this would have occurred under the care of the Master Gunner. His role on board, alongside the archaeological and historical evidence, will be discussed and scrutinised in the results and discussion chapters with regard to the organisation and maintenance of the gunnery system on board the *London*. Of the 325 crew and other guests there were only 24 survivors found clinging to upper stern structure, the only part of the ship that remained above the water (Anderson 1929, p. 171, Fox 2011, p. 16).

Contemporary salvage

As much as this was a tragedy, there were 76 highly valued and needed bronze guns now on the riverbed, so the attention of the Navy and Ordnance Boards was quickly directed to the recovery of those guns. Undamaged recovered guns could be redeployed to other vessels, so it was worth the effort to salvage as many as possible. Initially, the stern end of the *London* was still visible above the water, so it was possible to salvage six of the quarter deck guns almost immediately (TNA PRO30/37/8 and TNA WO51/5). For the remaining guns, divers, with the use of a diving bell, were employed and by October a further 18 guns were recovered (TNA SP29/135f.71). That appears to be it until a private contractor, William Harrington, reignited salvage operations in 1679. Between 1679 and 1690, with the use of a mechanical grab, Harrington recovered another nine bronze guns. In doing so, it is likely that he caused great damage and dispersal of the wreck, which has contributed to its current condition (TNA PC2/68 and PC2/73).

Modern salvage

In 1961 the Port of London Authority (PLA) conducted clearing operations over a rediscovered 19th century wreck and in doing so unexpectedly dragged up a bronze demi-culverin in their wire sweep (Jefferis and McDonald 1966, p. 182). Little did they know at the time that the later wreck had come to rest alongside an unknown and substantial piece of the

London. The gun was French in origin and dated to 1636, having ended up in English hands following the capture of any number French vessels between 1650 and 1654 (Fox 2011, p. 30). This gun is currently on display at the Royal Armouries Museum and Fort Nelson (Figure 3.2). The discovery of this gun was the first hint that this was the location of one part of the *London.*

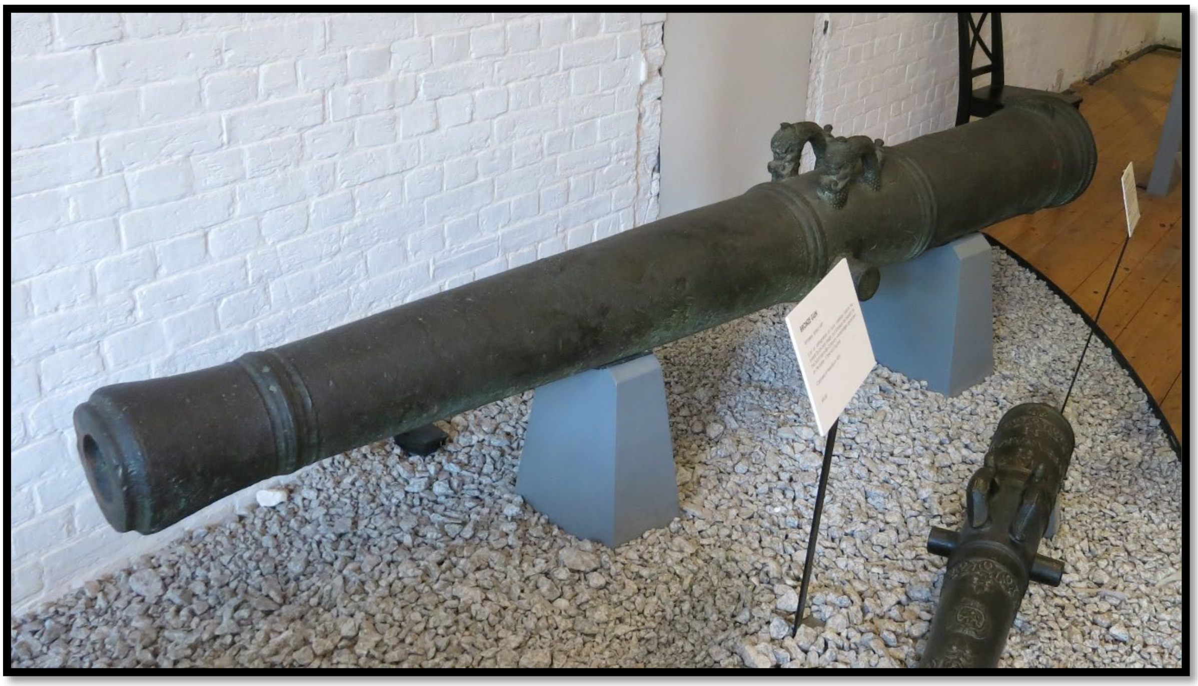

Figure 3.2: The 1636 French demi-culverin recovered from Site 2 in 1961 now on display at Fort Nelson, Portsmouth (Photo by author).

The PLA recovered two bronze guns in 1980 from a different area - Site 1 - but the description or current whereabouts of these are unknown (Fox 2011, p. 30). In 2007 five guns were illegally salvaged from the site where the French demi-culverin was recovered, which is now referred to as Site 2 (Pascoe 2017b, p. 41). They were all bronze, consisting of one Commonwealth demi-cannon, cast in 1656 by George Brown; a Tudor culverin cast in 1595 and later bored out to a 24-pounder; and three Dutch 24-pounder cast in 1616 and 1617. These guns were all part of the *London's* main gundeck arrangement, suggesting that this piece of the wreck consisted of a substantial part of the gundeck. The recovery of the demi-culverin from Site 2 in 1961 suggests that part of the hull survived at some point up to at least the upper deck, where the demi-culverins were located. Demi-culverins were also located from Site 1 on the stern quarter deck.

3.3.3 *Site location discovery and description*

The sites have been known by the PLA at least from 1961 but archaeological investigations officially began after their designation in 2008 under the Protection of Wreck Act 1973 (Wessex Archaeology 2010, p. 2, 2011, p. 2). Archaeological and geophysical investigations have confirmed the remains of the *London* are in two distinct areas, 400m apart, and referred to as Site 1 and Site 2 (Wessex Archaeology 2011, p. 2, Pascoe 2017a, p. 31). They are located on the northern edge of the main shipping channel in the Thames Estuary, adjacent to town of Southend to the North (Figure 3.3).

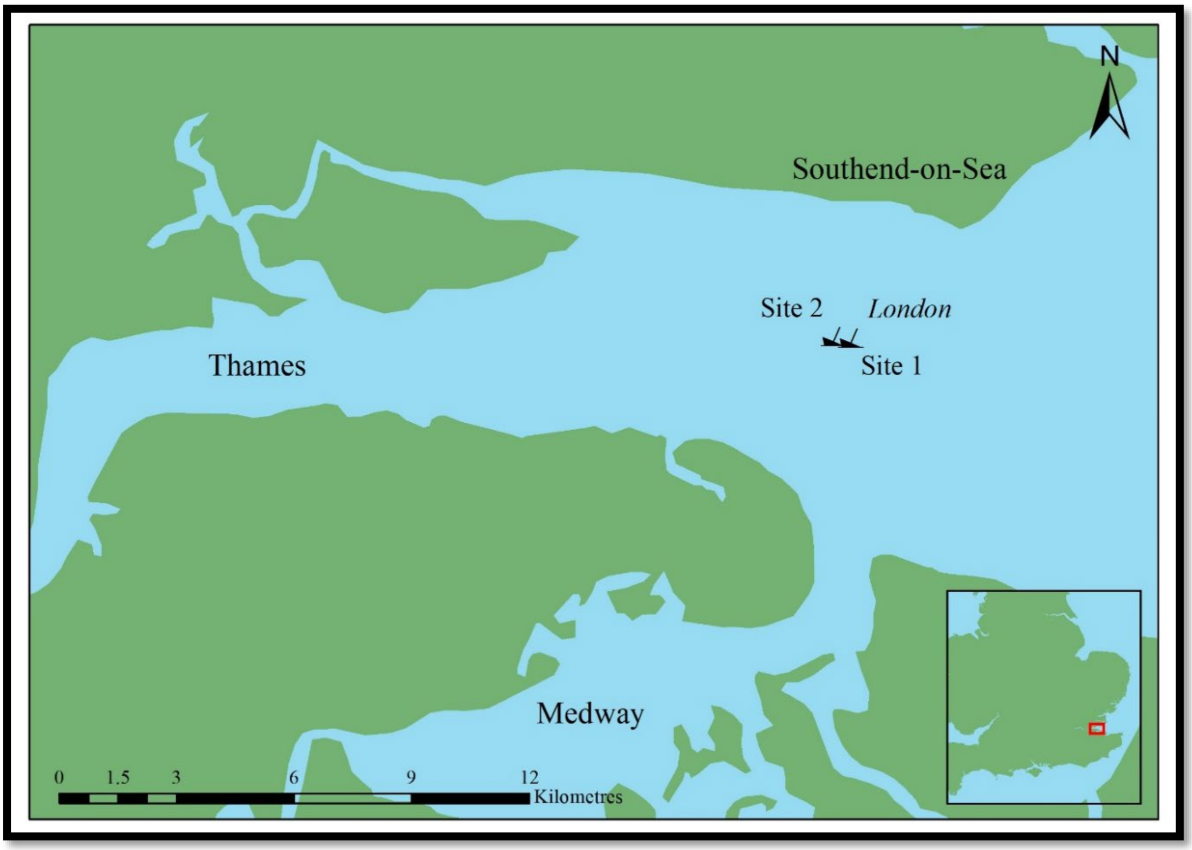

Figure 3.3: The *London* site locations (Image by author).

Site 1

The shallower site, Site 1, represents the probable location where the ship blew up, sank and where the contemporary salvage of the ship's guns was most likely conducted. Shortly after the loss of the ship, only the upper parts of the stern remained above water long enough for quarter decks guns to be salvaged. This would have only been possible at the shallower location of Site 1. Current work has identified three areas of exposed wreck material consisting of articulated pieces of hull structure at the south and north ends with a stack of at least two layers of heavily concreted iron guns in the central part of the site (Figure 3.4).

Their stacked nature and the fact they are iron demonstrate these guns were used as ballast and not as the armament. Diver observations suggest the extent of the site is larger than is currently exposed and it is likely that the iron guns are lying on top of a section of the lower hull, which is currently buried.

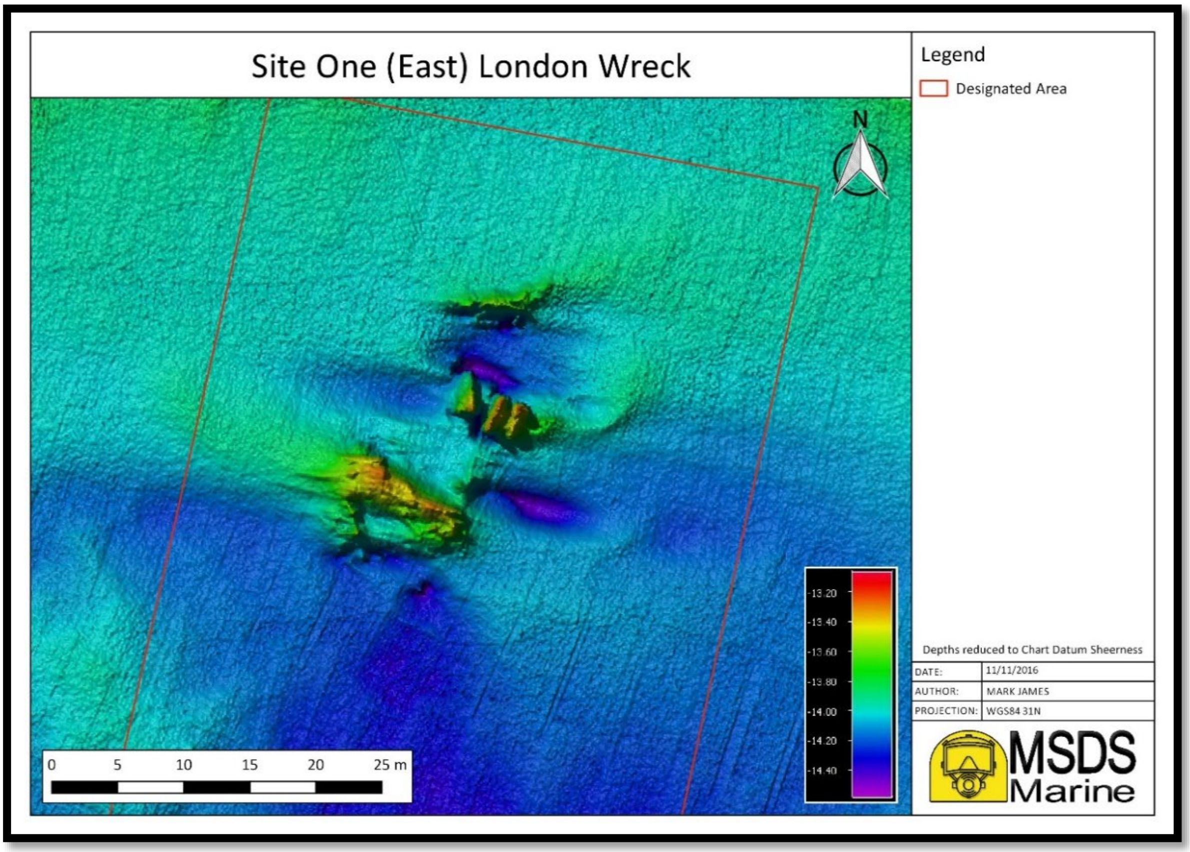

Figure 3.4: A mutli-beam bathymetry image of Site 1 of the *London*, (Image courtesy of MSDS Marine).

Site 2

Site 2 represents a large coherent section of the hull that parted from the main section of the ship during the explosion and drifted upriver on the flood tide. To confuse matters more, it is in fact the site of two shipwrecks, including a later 19th century ship found at the south end (Wessex Archaeology 2011, p. 19). Site 2 is located closer to the edge of the main shipping channel, which has been a major contributing factor to the site's vulnerability and current extent of exposure. This has led to more focused archaeological investigations aimed at identifying which part of the *London* Site 2 represents and the recovery of vulnerable and at-risk material (Cotswold Archaeology 2014, 2015, 2016). The section of the *London* at Site 2 is 30m long by 8m wide and recent excavations have confirmed an extant section of hull, lying inside up from the main gundeck down to the floor, near to but not including the keel

(Figure 3.5). The excavations also found a high density of artefacts in the excavation trenches, demonstrating the potential for high densities of artefacts across the whole site (Cotswold Archaeology 2016, Pascoe 2017a). Site 2 and the material recovered from it are the focus of this research.

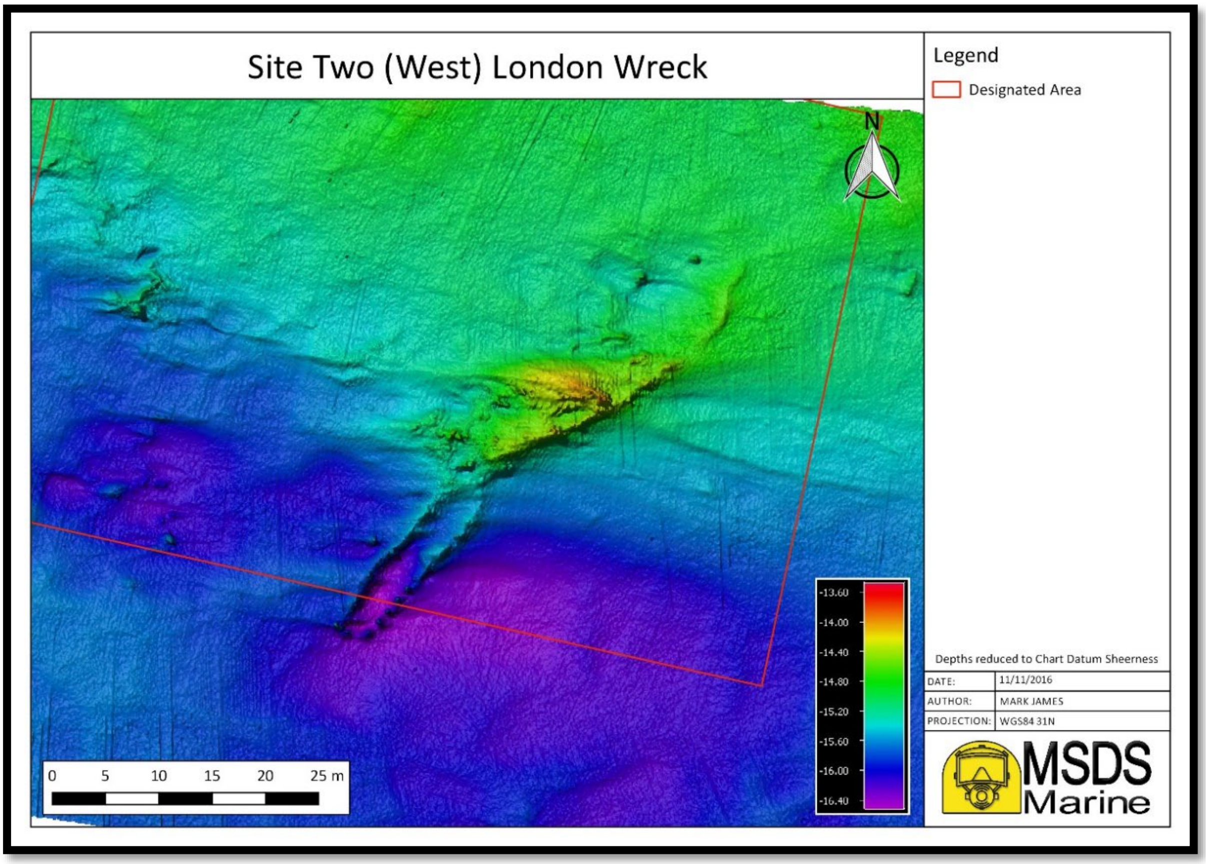

Figure 3.5: A multi-beam bathymetry image of Site 2 of the *London* (Image courtesy of MSDS Marine).

3.4 The *Hazardous* (1699 - 1706)

The *Hazardous* is the main case study in chapter six representing the period immediately after the end of the third Anglo-Dutch War up to its loss in 1706.

3.4.1 *Historical background*

Originally *Le Hasardeux*, the ship was designed and built by Pierre Coulomb at Port Louis, near the Lorient Dockyard, and launched in 1699 (Figure 3.6 represents a similar vessel to *Le Hasardeux*). Armed with 50 guns, consisting of twenty-two 18-pounders on the main deck, twenty-two 12-pounders on the upper and six 6-pounders on the quarter deck, *Le Hasardeux* was initially classed as a fourth-rate but was upgraded to a third-rate in 1701 (Winfield and

Roberts 2017, p. 133). In 1703 the French navy had loaned *Le Hasardeux* to the shipowner and privateer, Beaubriant-L'Évéque, from St Malo (Owen 1988, p. 285, Winfield and Roberts 2017, p. 133). By November, while under the command of Captain La Rue, *Le Hasardeux* ventured into the sight of a squadron of three English warships patrolling the Atlantic of the northern coast of Spain and was subsequently captured. The official reports acknowledged that La Rue and his crew put up a strong defence for six hours before striking colours (Owen 1988, p. 285). Great damage was inflicted on *Le Hasardeux* but the length of the engagement against three English warships demonstrated both the resistance of the French crew as well as the fighting capabilities of the ship and, therefore, its worth to the Royal Navy as a captured prize.

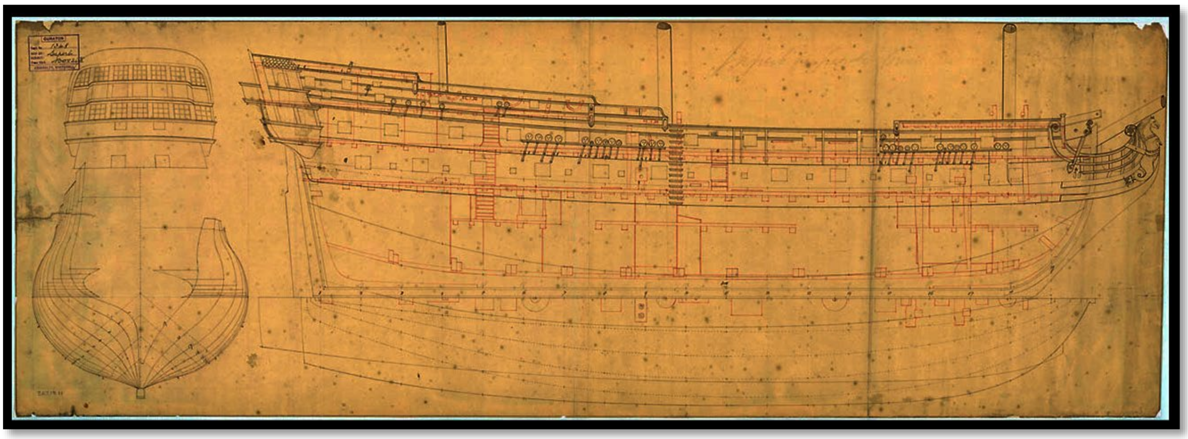

Figure 3.6: No plans of the *Hazardous* survive but this plan of the *Superb* another French ship captured by the English in 1710 was similar in size and design to the *Hazardous* (Image J4012© of the NMM, Greenwich, London).

Le Hasardeux, now known as the *Hazardous Prize* (referred to as the *Hazardous* from now on*),* was towed back to Falmouth where some initial repairs were made before sending her to Plymouth dockyard to be surveyed and valued. By March 1704 the dockyard surveyors believed she would make a very good 60-gun ship capable of carrying the crew for a fourth-rate of that number of guns (TNA ADM106/594/45). This was 10 more guns than she was captured with, demonstrating that she was not utilising all the gunports that she was designed with. The survey at Plymouth found that the *Hazardous* could carry 24 guns on the main and upper gundecks, 10 on the quarter deck and two on the forecastle (ADM 106/594/45). While the ship was being used in privateering, space and weight would have been shared with the storage of cargoes, with guns often omitted to reduce weight and make space. When recommissioned as a ship of the Royal Navy the weight of ordnance was the priority, leading to an increase in the ship's armament from 50 to 54 guns. Except for one broken 18-pounder, the surveyors found the French guns to be perfectly suitable to remain on board. A letter from the *Hazardous'* newly appointed Captain, Barrow Harris, confirmed the ship was issued with 22 guns on the main and upper decks and 10 on the quarter deck (TNA ADM 106/ 586/28), with the weights suggesting they were indeed the French guns rather than English (Personal communication Ruth Brown, ordnance specialist). On the 27th March 1704 the *Hazardous* was commissioned into the Royal Navy as a fourth-rate of 54 guns and with a crew of 320 (Owen 1988, p. 285).

The *Hazardous* started her service career as part of Sir Cloudesley Shovell's Channel fleet and, in May 1704, took part in the blockade of the Port of Brest but saw no direct action and returned to England by June (TNA ADM 51/4217). The *Hazardous* then spent the next year carrying out escort duties for merchant fleets transiting in the waters of the east Atlantic and English Channel (TNA ADM 51/4217). The Captaincy of the ship was handed to Richard Browne in December 1705 and the ship was given orders to sail to Virginia to escort a large merchant fleet back to England (Owen 1988, p. 286). This would turn out to be the *Hazardous'* last operation.

During the early 18th century there was a concentrated effort by the French to engage in a privateering war against trade with England. This resulted in considerable success with a contemporary claim of the loss of 3,600 merchant ships through French privateering (Rodger 2005, p. 177). The Royal Navy's response was to provide escorts for the many convoys of merchant fleets engaging in trade for England. The French privateering war appeared to have a greater effect on the capabilities of the Royal Navy than it did on foreign trade. They adapted from a top heavy battle fleet into a versatile sea-control force with the production of a greater number of more mobile trade defence vessels focused on convoy escort (Lambert 2019, p. 277). It ultimately led to the Convoy and Cruisers Act of 1708 making trade defence law (Lambert 2019, p. 277).

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The losses of merchant ships to French privateering demonstrated that the escorting of convoys was a necessary but dangerous duty with high potential of engaging with the enemy to protect the convoy. In convoy duties, the escorts were in many respects more vulnerable than when part of a fleet or squadron of warships as it was possible that the attackers had numerical supremacy regarding warships. In the acts of defending the convoy and allowing them to escape from the aggressors one could become isolated and out gunned. The crew and officers of escort ships, therefore, had to be equally prepared for a fight, as they would in any other operation, and have the abilities to carry out similar tactics to those performed in fleet actions. Rodger provides a good example of this when he describes how, in 1704, Captain John Evans formed a line of battle formation with his own four escorts ships and the ten largest merchant ships from a Virginia convoy to scare off six French warships (Rodger 2005, p. 176).

Although, the *Hazardous* may not have been a front-line ship of the line at the time of her loss, the duties of an escort ship were no less dangerous. Potential conflict was never far away during these turbulent times, so the *Hazardous* was armed and the crew prepared in a similar manner to a ship of the line in fleet actions or home cruising squadrons. As such, the archaeological evidence from *Hazardous* is equally as important and relevant as the evidence from the other case studies in this chapter: the grander ships of the line, *Stirling Castle* and *Northumberland*.

3.4.2 *The wrecking and contemporary salvage*

The Wrecking

By 13th November 1706 the *Hazardous* managed to cross the Atlantic from Chesapeake Bay, Virginia with a dispersed and depleted convoy of merchantman, having lost many ships on the way due to bad weather. In sight of Start Point, off the coast of Devon, the *Hazardous* and remaining convoy were met by another fourth-rate, the *Advice*, commanded by Captain Lowen (TNA ADM52/190). Lowen was tasked with leading the convoy down the English Channel to the Downs, off Kent. The conditions were poor at the time and Lowen decided to push on instead of taking temporary shelter in Plymouth. The *Hazardous* had also just lost their captain to disease and the command of the ship was handed to Lieutenant Hares (TNA ADM1/5266).

By the 18th November the convoy was off the coast of the Isle of Wight and, with conditions worsening, the *Advice* made the decision for the convoy to head for the shelter of St Helens Roads, a protected naval anchorage off the east coast of the Isle of Wight. In dark and deteriorating conditions, the *Hazardous* followed the *Advice* but either the *Advice* failed to signal or the *Hazardous* did not see the signal that shoal water was nearby. The *Hazardous* was driven northeastwards into shallow waters forcing her to drop anchor. Unfortunately, the anchor failed to hold and the ship grounded and bumped along the bottom throughout the night until the commander Lt Hares decided the best course of action to save the ship and crew was to cut away the anchor and drive the ship as close to shore as possible. Shortly after 0800 in the morning on the 19th November 1706, the *Hazardous* was run ashore and wrecked in Bracklesham Bay, West Sussex; Lieutenant Hares' actions had managed to ensure that most on board made it ashore alive (TNA ADM1/5266).

Contemporary salvage

Due to the shallow nature of where the ship was lost, parts of it remained above water enabling persons to clamber aboard to assess the wreck within days of the loss and when conditions allowed. Lieutenant Hares reported on the 29th November that a great deal of the small arms were recovered and, regarding the great guns, that it might be possible to save the upper and quarter deck guns but those below were underwater (Owen 1991, p. 330). By the 24th January it was reported that some guns and stores had been recovered and salvage would continue when the weather allowed. It would seem to suggest that salvage operations were regularly interrupted by poor conditions.

By the 6th June 1707 it was reported that 21 guns and other gunner's stores had been saved (TNA ADM106/625/145). The wreck continued to break up and when a large section of one of the ship's sides parted and drifted onto the beach at Selsey it was recommended that the wreck was sold (TNA ADM106/624/216). On the 15th September 1707 the decision was made to put the wreck up for public sale (TNA ADM 106/624/216) and on the 20th October 1707 the wreck of the *Hazardous* was bought by John Day from Emsworth (TNA ADM 106/624/268). Currently there have been no records found indicating what John Days managed to salvage from the wreck, likely due to the Navy losing interest once it was sold.

The guns, however, were the property of the Board of Ordnance and there are two notes within Ordnance Office administrational documents regarding guns from the wreck of the *Hazardous* (TNA WO47/28 and WO47/29). There is some confusion as to whether these notes are referring to new recoveries of guns or to previous recoveries that were only just being dealt with by 1715. For the purpose of this research, only the guns reported by the 6th June 1707 will be taken into consideration.

From the records it is possible to deduce that at least 21 guns were recovered and that some amounts of gunner's stores were also salvaged. This salvage will have affected the archaeological evidence found on the seabed and will be taken into consideration when interpreting the archaeology in chapter six.

3.4.3 *Site location, discovery and description*

The wreck of the *Hazardous* is located 800m off the beach, southeast of the public slipway at Bracklesham Bay, West Sussex, in a general depth of 7m at high water (Owen 1988, p. 287) (Figure 3.7). The site was rediscovered in 1977 and designated in 1986 as a protected wreck under the Protection of Wreck Act 1973 (Owen 1988, p. 287). Site investigations have been conducted since its discovery by the 308 Club Branch of the Sub-Aqua Association and now the Hazardous Project Group (HPG), whose founding members originated from the 308 Club.

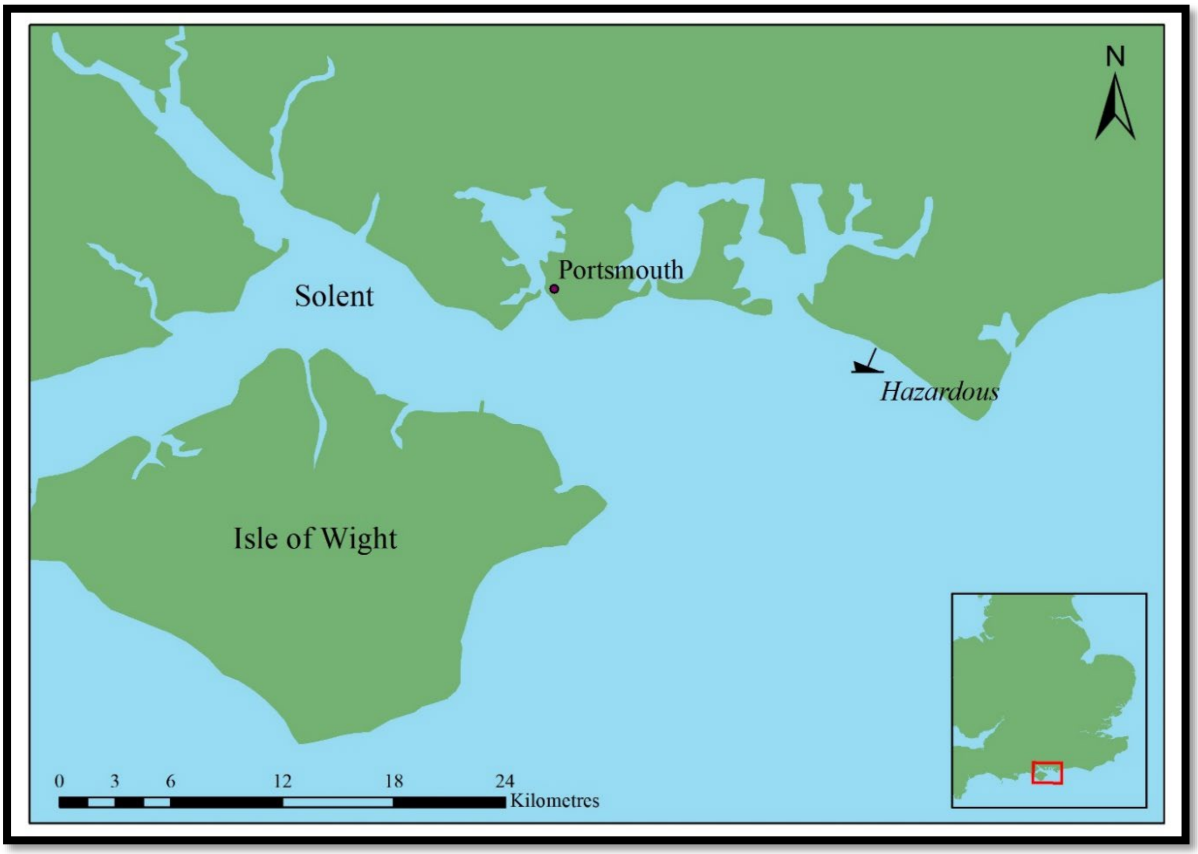

Figure 3.7: The *Hazardous* site location.

The current extent of the site is contained within the boundary of a designated area with a radius of 150m (Figure 3.8). This contains three distinct areas of wreck material relating to the *Hazardous*, referred to from this point forward as the main site, the 2014 gun site and the 2019 gun site (Figure 3.8). The label of the latter two referring to the year those areas of the site were found. The main site contains the most coherent and well-preserved part of the wreck, consisting of a large section of the port side hull extending from roughly amidships to the bow and from the main gundeck to the keel. The sediments within the structure have preserved a high density of artefacts, many of which are gunnery related. The extent of the preservation of both structures and artefacts classifies the *Hazardous* as a class 1 shipwreck and, alongside the gunnery related material observed and recovered, are the reasons why it has been chosen as a primary case study.

The 2014 gun site is 110m WSW of the main site and consists of 10 concreted iron guns and scatters of round and double head shot (Figure 3.8). Other loose artefacts have been found but in small numbers. The 2019 gun site is 100m WNW of the main site and consists of 11 concreted iron guns, an anchor and scatters of round and double head shot (Figure 3.8). There are also high densities of other finds, such as large amounts of lead musket and pistol shot, silver specie and cooking vessels. The centre of the 2019 gun site is 80m north of the centre of the 2014 gun site. The artefacts found at the southern end of the 2019 gun site appear to be part of debris trail that possibly leads all the way back to the 2014 gun site. This suggests that the initial wrecking point was at the location of the 2014 gun site where the loss of 10 guns and shot lightened the ship allowing her to drift north while spilling other objects on the seabed. A lone gun (Figure 3.8) and a timber spar, among other artefacts, were located in two separate areas between the northern end of the 2019 gun site and the main site. This suggests that following the loss of another 10 guns and an anchor, the *Hazardous* lightened again and drifted east spilling another gun and other objects before drifting south to where the main site is now located.

As the label of the 2019 gun site suggests, this area of was found during the research of the thesis and further extensions to this were found during the summer of 2020. These recent discoveries have contributed greatly to this research and, combined with the 2014 gun site, provide evidence relating to the type and organisation of gunnery related material found on the *Hazardous'* upper and quarter decks.

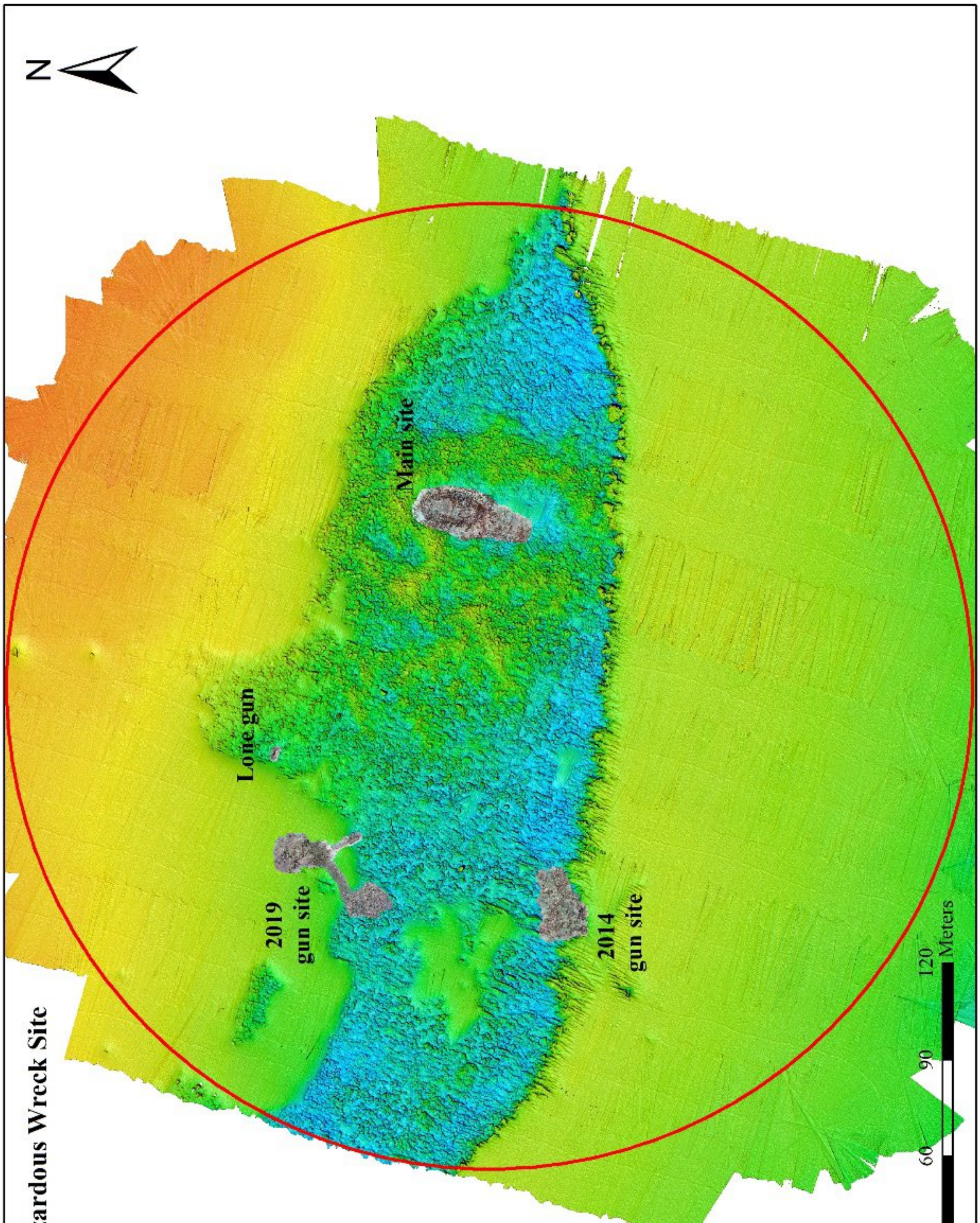

Figure 3.8: The designated area of the *Hazardous* showing the different areas georeferenced onto the 2020 multi-beam bathymetry (Multi-beam courtesy of the HPG).

3.5 The *Invincible* (1744 – 1758)

The *Invincible* is the main case study in chapter seven and represents the second quarter of the 18th century up to the loss of the *Royal George* in 1782.

3.5.1 *Historical background*

By the turn of the 18th century the overseas territories of the major European powers had expanded in trade and importance and by the 1730s were a vital resource for their growing economies (Lavery 1988, p. 3). A new type of war therefore developed that would be fought-out all over the world and the protection of colonies and their trading fleets became a growing necessity. The French naval administration, under the leadership of Maurepas, responded by developing a fleet that could defend the overseas Empire, rather than directly take on the British head-to-head (Rodger 2005, p. 409).

Key to the success of this was the design of a new type of warship that was as good at sailing as it was at fighting; the slow lumbering three deckers were not suitable for this task. Instead, the ship constructor, Francois Coulomb, designed a new type of 74-gun ship. Coulomb increased the hull length allowing room for an extra gun port on each side of the upper and main gundecks. This enabled the ship to carry 74 guns without the need to place guns higher up on the poop decks, increasing fire power while simultaneously lowering its centre of gravity (Lavery 1988, p. 3). Coulomb's ship the *Terrible* was launched in 1739 and within two years another two of this new type of 74 were under construction, the *Invincible* and the *Magnanime* (Lavery 1988, p. 3). *Invincible* was the second ship of this type to be constructed and the wreck is the earliest survivor of the 74-gunship lineage, a type that would become the backbone of all the most powerful navies in the world.

The construction of the *Invincible* began in 1741 on the banks of the River Charente at Rochefort, under the control of the constructor Mourineau, and the ship was launched on the 21st October 1744 (Lavery 1988, Bingeman 2010). The gun decks of the *Invincible* and the other new 74s were not only longer, allowing for extra gun ports, but critically the main gun deck was six feet above the waterline (NMM POR/D/9). This was in contrast to the British first and second rates, which were only three to four feet, resulting in all but the calmest of seas restricting the ships to the use of two gundecks instead of three (Baugh 1977, p. 195, Lavery 1988, p. 27). In these cases they would also be without the use of their heaviest guns and were potentially at a significant disadvantage against the French 74s.

Invincible, however, did not have a long service career in the French Navy. While escorting a French East India Fleet she was captured by a superior British fleet, under the command of Admiral Anson, off the Northwest coast of Spain at the first battle of Cape Finisterre on the 3rd May 1747 (Lavery 1988, p. 21). The *Invincible's* qualities of speed and maneuverability had been restricted by the necessity to hold back and protect the fleet. Following the battle and despite her battered condition Anson was immediately impressed by the design and structure of *Invincible*. In his dispatch back to the Admiralty he records how the length of *Invincible's* main gundeck was over seven feet longer and even the breadth was greater than his 90 gun three decker, the *Prince George* (Lavery 1988, p. 26). The *Invincible* was also approximately 50 per cent larger in tonnage and, with a main gundeck armament of 36-pounders and upper deck of 18-pounders, fired a broadside 75 percent heavier than the British 70-gun ship (Rodger 2005, p. 413). The new French 74s stood out immediately by dwarfing the British third-rate and many second-rates. Anson recognised the shortcomings of British ships and realised that the design of *Invincible* and other 74 prizes were the future of British warship design (Figure 3.9).

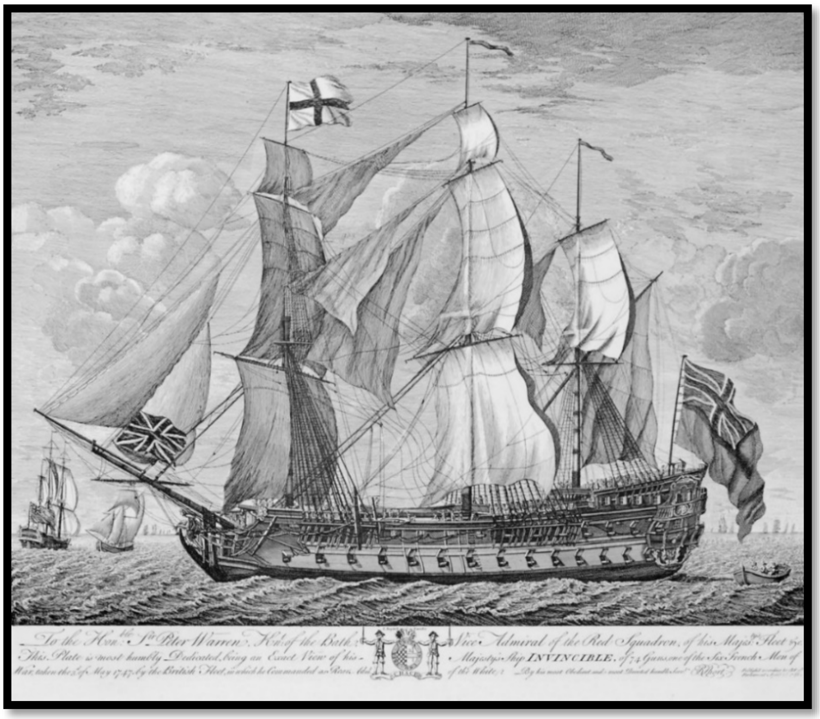

Figure 3.9: *Invincible* commissioned into the Royal Navy following her capture in 1747. A plate from Spoils of War, portraits of the French and Spanish ships taken by Lord Anson. (Author's collection).

By early 1748 the British had captured many of the best ships in France's Navy including four of new 74s (Lavery 1988, p. 43), but why were these superior French vessels being lost to the British? Was it simply that they were overwhelmed by greater numbers and restricted by their convoys or can the reason be attributed, in part, to other factors, such as better tactics, gunnery or seamanship by the British? The archaeology from *Invincible* presented in chapter seven will help provide an answer.

Peace time within a year of her commissioning into the Navy and then major repairs to the ship between 1753 and January 1756 led to little opportunity for the Royal Navy to make best use of the *Invincible*. This changed, however, with the re-ignition of war with France in 1755 (the Seven Years War 1755-63) and *Invincible* emerged from her great repair with a delivery of a new lightweight 24-pounder to replace the 18-pounders on the upper gundeck, an even heavier broadside. Along with the new guns came a duty worthy of *Invincible's* pedigree, reinstatement as a flagship of the Western Squadron, under the command of Admiral Boscawen. The Seven Years War was a global conflict fought across North America, the Caribbean and the East Indies; exactly the type of conflict the *Invincible* was designed for. The Western Squadron was the most important command in the Navy with the responsibility of patrolling the western approaches to the English Channel and sabotaging French naval and commercial activities from the Atlantic ports of Brest, Rochefort, Le Havre, St Malo, Nantes and Bordeux (Rodger 2005, p. 264). These Atlantic ports were essential to the French for reinforcing the colonies of the Caribbean, North America and India (Lavery 1988, p. 70). Despite the *Invincible* being at sea for several months the fleet did not see any meaningful action to test the skills of the *Invincible* crew's gunnery. The captain's log, however, does record that the great guns were exercised with live firing using different shot aimed at a target (TNA ADM 51/471). Along with the trial of the new 24-pounders *Invincible* was also trialing the use of gunlocks with the 9-pounder guns on the quarter deck (TNA ADM 2/214), to determine whether these were a more reliable method of firing.

In 1757 *Invincible* was given orders to sail to North America to reinforce Vice-Admiral Sir Francis Holburne's squadron and assist in regaining the fortress of Louisbourg from the French. This operation was not successful and almost ended in disaster when the fleet was caught out in a hurricane, which caused serious damage to several of the fleet, including the *Invincible. Invincible* limped back to Portsmouth on the 9th November 1757 and extensive repairs were made. Following the repairs the ship was told to prepare for a second voyage to Louisbourg and by February 1758 was at anchor off the east coast of the Isle of Wight awaiting the signal to set sail (Lavery 1988, Bingeman 2010).

3.5.2 *The wrecking and contemporary salvage*

At 2.30 am on the 19th February 1758 the crew of the *Invincible* saw the signal for the fleet to weigh anchor and set sail for their voyage to Nova Scotia, to oust the French from the Fortress of Louisburg (TNA ADM51/471). The *Invincible*, therefore, was fully stored and armed for foreign service.

Unfortunately, the *Invincible* did not make it out of the Solent as a series of calamitous events led to the ship running aground on a shallow sand bank in the eastern Solent, only a few hours after weighing anchor (TNA ADM 51/471). Attempts were made to lighten the ship by throwing six upper gundeck guns over the side, lowering three of the quarter deck guns into the long boats, as well as emptying barrels of beer and water (NMM ADM/L/J/87). This was all to no avail as the ship had scoured a deep hole that it could not get out of. By the 22nd all the other guns and carriages along with a significant amount of shot, gunner's stores and lumber were transferred onto other vessels assisting from Portsmouth Dockyard (NMM ADM/L/J/87 and TNA ADM 51/471). All hopes of saving the ship were lost when she fell violently over onto her port beams ends (TNA ADM 51/471). Due to the shallowness of Horse Tail Sand the upper parts remained above water for several months, during which time other stores that were accessible, masts and rigging were salvaged (Lavery 1988, p. 104).

3.5.3 *Site location, discovery and description*

The site of the *Invincible* lies on the northern edge of a sandbank known as Horse Tail Sand in the Eastern Solent, approximately three miles offshore from Portsmouth Harbour (Figure 3.10).

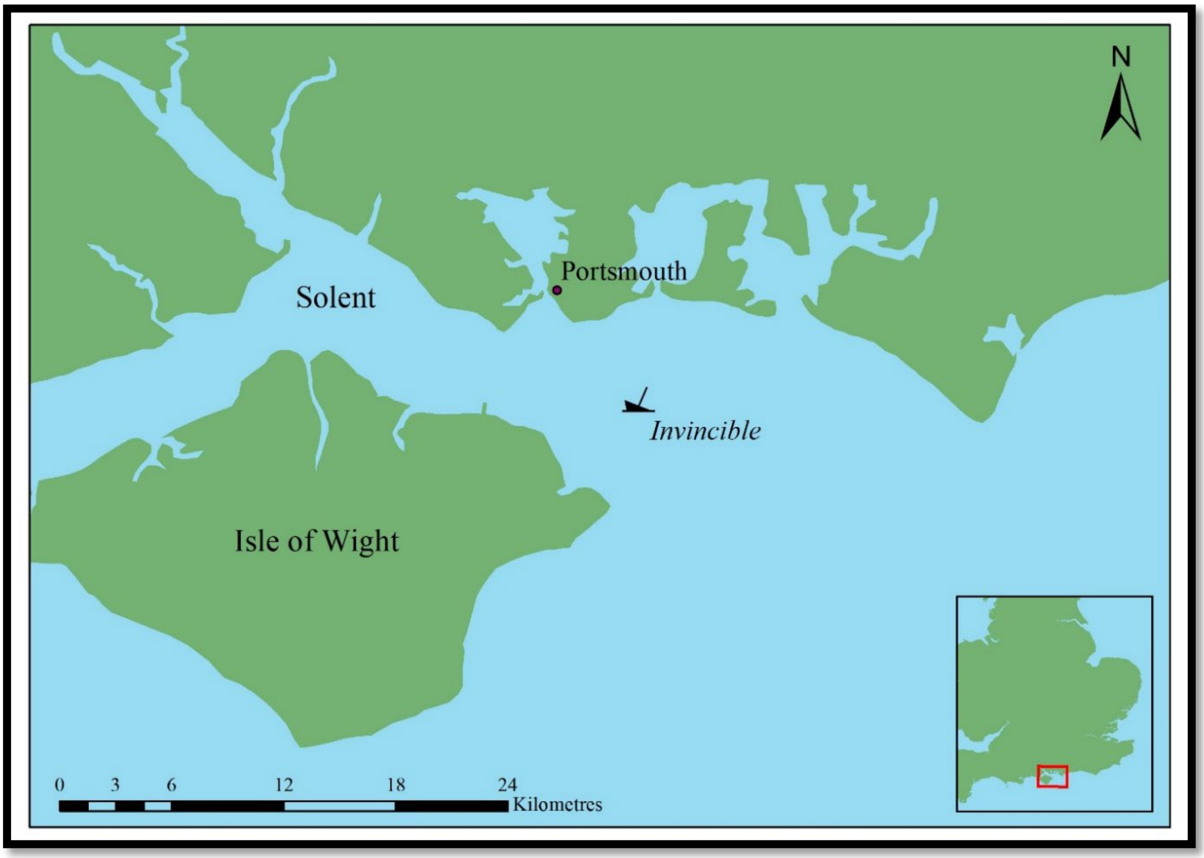

Figure 3.10: The *Invincible* site location.

It was discovered by local fisherman Arthur Mack in 1979. Understanding the significance of the site, Arthur enlisted Commander John Bingeman to archaeologically investigate the wreck (Lavery 1988, Bingeman 2010). John had previous experience of coordinating archaeological investigations on the sites of the HMS *Pomone* and HMS *Assurance*, wrecked on the Needles. The wreck of the *Invincible* was an ideal candidate for designation under the Protection of Wrecks Act 1973 and thus the site was designated in 1980 and John became the Licensee (Pascoe and Cowan 2017).

John led numerous surveys and excavations on the site between 1980 and 2010. The results of this work revealed that the portside was intact from bow to stern and from parts of the gundeck down to the floor timbers, with thousands of artefacts preserved within (Figure 3.11). These related to all aspects of shipboard life and their recovery and subsequent study has offered a unique insight into life on-board a ship in the Georgian Navy. The history of the site's investigations up to 1991 can be read in Commander John Bingeman's publication, *The First HMS Invincible (1747-58) Her Excavations (1980-1991).* Surveys during that time also revealed that the starboard side had broken away from the port side and lay to the north in several large but predominantly buried coherent chunks.

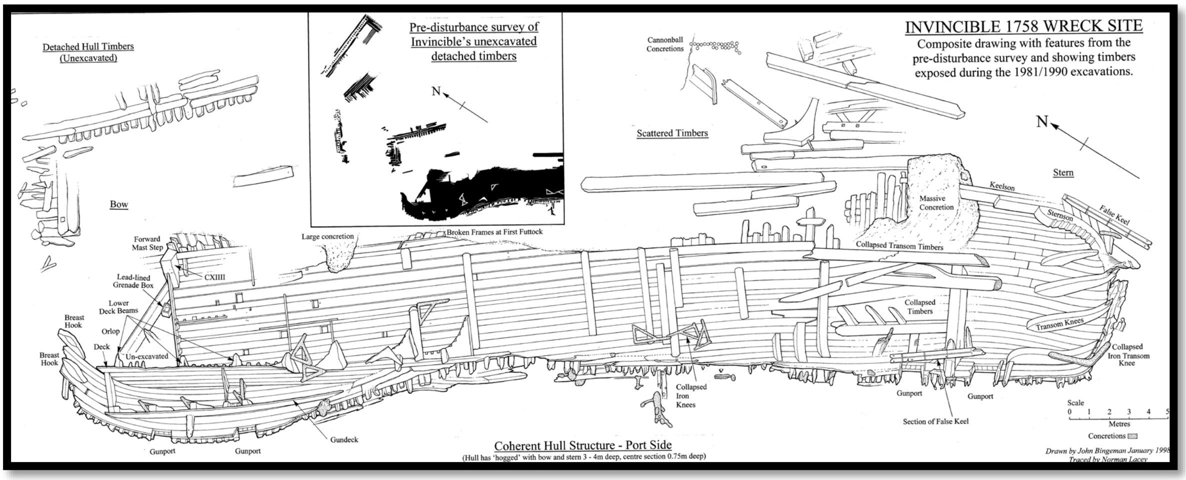

Figure 3.11: 1998 composite plan showing the excavated port side with darkened inset showing exposed starboard side (Bingeman 2010, p. 58).

In 2010 the responsibility of the site was passed on by John Bingeman and Historic England to myself. Since then seabed levels have continued to drop due to a combination of the southward migration of Horse Tail Sand and the shallow depth of the site leading to increased scour from high-energy wave action. This has caused further exposure of the site revealing unexcavated and artefact rich areas of the port bow and a huge extent of starboard structure (Pascoe and Cowan 2017, pp. 18–19) (Figure 3.12). The section of the port bow includes the location of the gunner's store, as well as other adjacent storerooms. The discovery of a well preserved 24-pounder rammer head in 2015, located a few centimetres to the north of the forward most orlop deck beam, suggests the potential for other gunner's stores to still survive in this unexcavated area of the ship (Pascoe 2015, p. 2). The record of the site's vulnerability led to the 2017-2019 excavations and the port bow was a particular area of focus, along with the remains of the gundeck on the port stern quarter. The archaeology relating to gunnery from both phases of investigations has been studied to form the basis of the interpretation for this research.

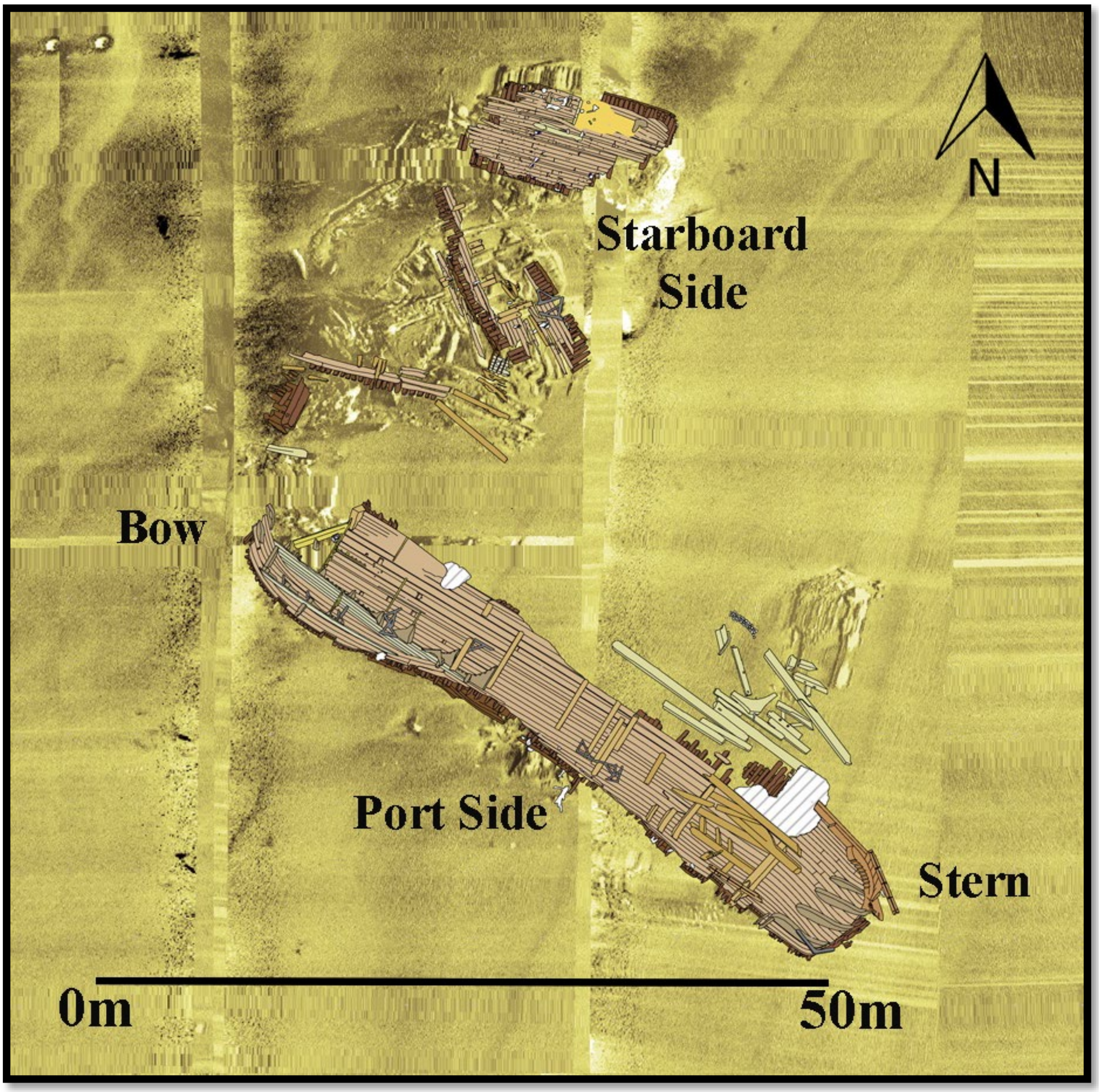

Figure 3.12: Colour coded drawings of Bingeman's excavated port side and exposed starboard side structure recorded by Pascoe Archaeology from 2012-2014. The drawing are overlaid over 2014 sidescan sonar data courtesy of Wessex Archaeology (Pascoe Archaeology 2015).

3.6 HMS *Colossus* (1787 – 1798) and HMS *St George* (1785 – 1811)

Two case studies have been chosen to represent the final period of this study, HMS *Colossus* and HMS *St George*. They represent the period of the Revolutionary and Napoleonic wars with France during the last decade of the 18th century up to the loss of the *St George* in 1811. Both can be classified as *class 1* shipwreck sites but the type and level of information gained from them are very different. The reason for this can be greatly attributed to each site's environment. It can be argued that both are located in dynamic locations where the shallow depths and physical action of the sea causes fluctuations in depth of the burial environment that has helped preserve these wrecks for the last 130 years. Periodically, however, the change has been more dramatic for the *St George* moving suddenly from total burial to rapid exposure, due to the migration of seabed sediments away from the site. This has resulted in very different approaches to dealing with the archaeology of both sites. In the case of the *St George* the response was more urgent, leading to rescue excavations during a period of exposure. The work prioritised the recovery of artefacts before they were inevitably lost if left on the seabed. The position of objects were recorded in relation to the hull structure and a basic recording of the surviving hull was made in plan view (Jepsen 2019, pp. 208–9). For the *Colossus*, on the other hand, seabed changes have occurred, but at a pace that has allowed greater opportunities to record the structures of the ship to a high level of detail before features were lost (Camidge 2001, 2002, 2006, 2007, 2008, 2009, 2010, 2012, 2017). As such, and for the purpose of this research, the wreck of the *St George* has provided evidence predominantly from artefacts and the *Colossus* from the very detailed recording of the hull.

3.6.1 *Historical background*

The archaeology of these two ships represent the last quarter of the 18th century up to the first 11 years of the 19th century. This was a period almost entirely devoid of peace between Britain and France, which drew many other northern and continental European nations into the conflict. As such, the Royal Navy was in operations all over the world's oceans but particularly so in European waters (Lavery 2009, p. 11). High activity promotes change and developments, and the archaeology from the *Colossus* and *St George* reflects this. Some of the technological improvements made to the gunnery system will be identified, but particularly evident from this period is another transformation in fighting tactics. The last hundred years were dominated by the extremely attritional tactic of forming the fleet or squadron into a single line against the parallel line of the enemy. The reason, as discussed in section 1.1, was it brought all the guns on one side to bear with a clear line of sight to the opposing fleet. The disadvantage of this was that the opposing fleet were doing the same and returning similar fire back. If neither side abandoned their line it often ended in stalemate (Lavery 2009, p. 255, Wilson 2014, pp. 373–74).

Nelson has taken most of the credit, but it must be said there were also others that tried the more audacious and aggressive tactic of dividing their fleet, squadron into smaller columns to attack perpendicular to the enemy's line, with the aim of slicing through and breaking it up.

This was known as ‘breaking the line’(Lavery 2009, p. 257, Wilson 2014, p. 369). It was extremely risky because at the start of the maneuver the most poorly defended and structurally weak part of the ship, the bow, was under direct fire from the broadsides of the opposing fleet. However, when passing between two ships of the enemy line their weaker bow and stern were then exposed to the broadsides on both sides, which could lay down raking fire causing maximum damage and carnage along the length of the decks of the opposing ships. When through, your ship would turn to engage the enemy on their other side, which was probably not prepared (Lavery 1983, p. 128, 2009, p. 257). This tactic breaks up the line and separates the ships of the opposing fleet making them more vulnerable and was the official fighting instructions of Nelson at the battle of Trafalgar in 1805 (Corbett 1905, p. 316).

This extremely aggressive tactic was only considered if the commanders, such as Nelson, had the confidence that the gunnery of the British were superior to their enemies. It depended, initially, on the crew holding their nerve in the approach under fire, followed by a high rate of fire at close range, once engaged. Along with great discipline and organization there were several improvements made to the gunnery system that may have contributed to the British gunners having an edge over their rivals. The archaeology from *Colossus* and *St George* will identify some of those improvements.

3.6.2 *HMS Colossus*

Colossus was a 74-gun *Courageux* class third-rate ship of the line, based on the lines of the French *Courageux*, and built by Cleveley at Gravesend in 1787 (Lavery 1983, p. 180, Birchall 1998, p. 236). At the time of her wrecking she carried twenty-eight 32-pounders on the main gundeck, twenty-eight 18-pounders on the upper gundeck, fourteen 9-pounders on the quarter deck and four 9-pounders on the forecastle (Camidge 2012, p. 10).

During *Colossus’s* 11-year service career she was an active vessel, involved in several key operations during the Revolutionary Wars. *Colossus* first saw active service in 1793 as part of Vice Admiral Lord Hood’s Mediterranean squadron, deployed in the Blockade of Toulon. Two years later she served in Lord Bridport’s fleet in the action off the island of Groix. In 1797 *Colossus* was one of fifteen ships in Admiral Sir John Jervis’ fleet that defeated a twenty-seven strong Spanish fleet at the Battle of Cape St Vincent. Nine of the 15 strong

British ships of the line were 74s, demonstrating the success of this type since the capture of *Invincible* in 1747.

Colossus led the van—a squadron of seven ships—to break between the Spanish line, which were in two distinct groups, and attack the main body of these ships from the rear (Sturges Jackson 1900a, p. 231, Birchall 1998, p. 236, Rodger 2005, p. 439). She lost her fore-topsail yard early in the engagement hampering the ship's maneuverability and forcing her to take a defensive stance for the remaining battle (Sturges Jackson 1900a, p. 231). *Colossus*, however, would have witnessed Nelson in the 74-gun *Captain* leave the British line with the support of only one other ship and break through the Spanish line, thwarting a Spanish counter attack (Sturges Jackson 1900b, p. 198, Rodger 2005, p. 439). This is an early example of Nelson using the tactic of breaking the line, which he would repeat at Trafalgar. The 74s were ideal ships for these aggressive tactics as they had the speed and agility to maneuver into attacking positions along with the weight of ordnance and strength of build to compete against the largest enemy ships (Lavery 2009, p. 46, Wilson 2014, p. 323). Once in position, and if up against a three-decker, the ships relied on their gunnery to win the battle.

By 1798 *Colossus* was deemed in a condition not fit for front line operations and was subsequently used as a store and transport ship for the wounded from the Battle of the Nile (Birchall 1998, p. 236, Wessex Archaeology 2003, pp. 11–12, Camidge 2012, p. 9). That was her final voyage, which ended in her wrecking in St Mary's Roads in the Isles of Scilly on the 11th December 1798 (Birchall 1998, p. 327, Wessex Archaeology 2003, p. 13, Camidge 2012, p. 9). Although *Colossus* was downgraded to transport duties the ship and crew still had to sail back to England via hostile waters and would therefore have been prepared for action if confronted by a foe. The remains on the seabed, therefore, still represent what was a fully armed and capable 74-gunship and the archaeology gathered from the site is crucial in understanding naval gunnery of this period.

3.6.2.1 The wrecking and contemporary salvage

Wrecking

On the 7th December *Colossus* took shelter on the lee of the island of St Mary's in the Isles of Scilly. During the next two days the captain recorded many defects of the ship, which may have been a contributing factor to the loss of the ship a few days later. Winds increased during the following days leading to the *Colossus* dragging her anchor and eventually striking the rocky bottom to the south of the island of Samson. By the 12th December the ship had turned onto her beams ends and started to break up (Wessex Archaeology 2003, p. 13).

Salvage

Both official and unofficial salvage operations were carried out on the wreck. Initially this was done under the supervision of Lieutenant Patrode of HMS *Fearless* who was employed by the admiralty to recover stores, rigging and guns. When the admiralty salvage operations had retrieved what they could, the islanders continued to work the wreck. The famous ship salvaging brothers Charles and John Dean reignited salvage operations on behalf of the Admiralty with the use of hardhat diving equipment in 1833. Records show that an unspecified number of guns were recovered along with other materials such as copper sheathing and nails (Birchall 1998, p. 237, Wessex Archaeology 2003, p. 15, Cornwall and Isles of Scilly Maritime Archaeology Society 2006, p. 7, Camidge 2017, p. 14).

3.6.2.2 Site location, discovery and description

The wreck lies to the south of the Island of Samson on the Isles of Scilly (Figure 3.13). Currently there are two known areas of the wreck plus a debris trail of material. An area believed to be the bow was discovered in 1974 by the salvor Roland Morris. This part of the site was subsequently designated in 1975 under the Protection of Wrecks Act 1973. A large quantity of broken ceramics belonging to Sir William Hamilton’s collection was found and recovered (Cornwall and Isles of Scilly Maritime Archaeology Society 2006, p. 10).

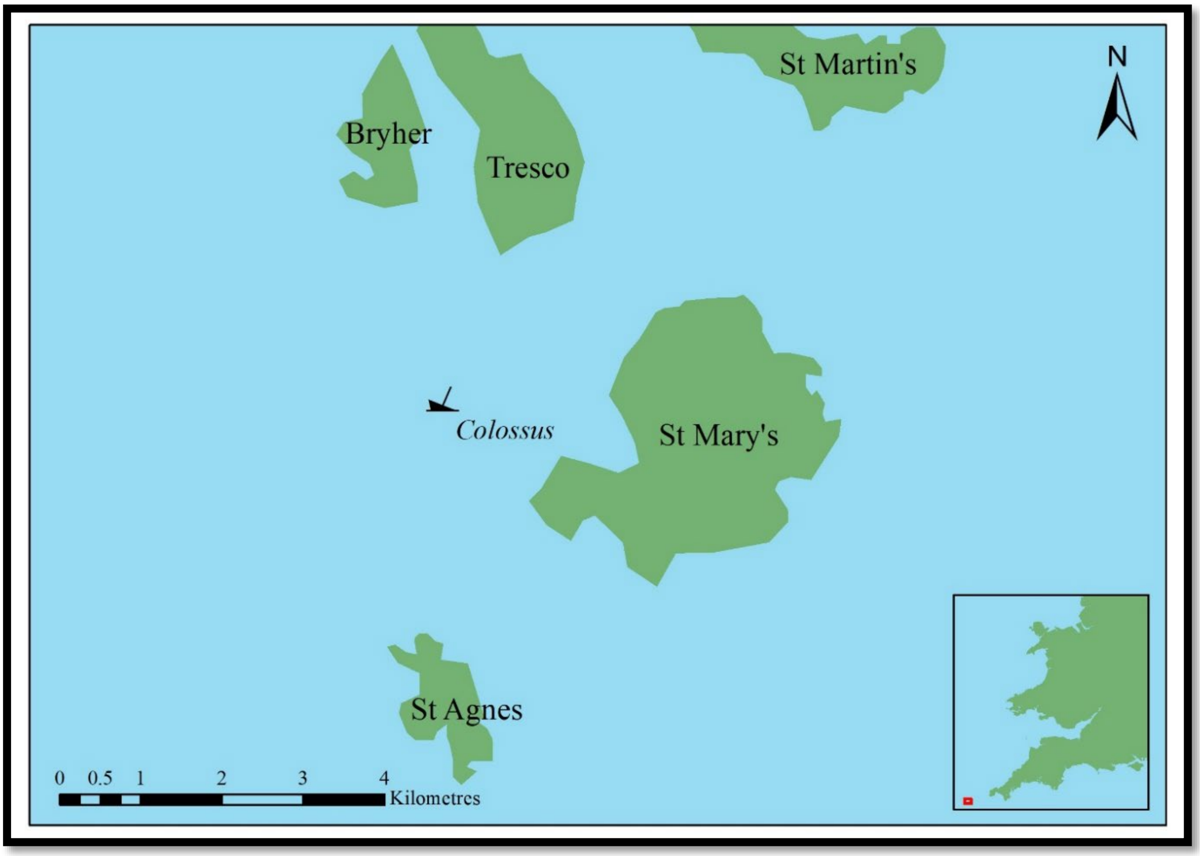

Figure 3.13: The *Colossus* site location (Image by author).

In 2001 a large section of the aft port side was found along with several guns and was designated in the same year. Investigations initially led by finder Mat Mace, and later by the Cornwall and Isles of Scilly Maritime Archaeology Society (CISMAS), led by Kevin Camidge, identified and recorded a 30m long section of the starboard side, from the quarter deck down to orlop and from the stern to roughly in line with the main mast (Camidge 2001, 2017, p. 16, Cornwall and Isles of Scilly Maritime Archaeology Society 2006). The structure lies inside up with five 18-pounder Armstrong pattern upper gundeck guns standing upright through their gunports (Camidge 2017, p. 17). A shallow layer of sand covers much of the inside of the structure with the ends of frames and beams exposed. This covering has preserved the internal structures, artefacts and fittings but dropping seabed levels overtime are exposing other surfaces (Figure 3.14). The recording of this this part of the site has provided a detailed understanding of the internal structural features of the orlop, main and upper gundecks. The details of the main gundeck will be a focal point of chapter eight.

Figure 3.14: The *Colossus* site plan. The stern end at the NE end (Courtesy of K.Camidge and CISMAS).

3.6.3 *HMS St George*

St George was a 98-gun *Duke* class second-rate ship of the line built at Portsmouth in 1785 (Figure 3.15). When she wrecked in 1811 she was armed with twenty 32-pounders on the main gundeck, thirty 18-pounders on the middle gundeck, thirty 12-pounders on the upper gundeck, eight 32-pounder carronades on the quarter deck and two 9-pounders on the forecastle (Teisen 1998, p. 258). In 1793 *St George,* like *Colossus,* was with Admiral Lord Samuel Hood's Mediterranean fleet during the blockade of Toulon. *St George* continued duties in the Mediterranean and in 1795, under the fleet command of Vice Admiral William Hotham, was involved in actions against the French including the defeat of the 17 French ships at the Hyéres Islands (Teisen 1998, p. 259, Jepsen 2019, p. 41). By 1801 *St George* was the flagship of Vice-Admiral Lord Nelson who was second in command to Vice-Admiral Sir Hyde Park of the Channel Fleet. The fleet was called into action at the Battle of Copenhagen but *St George* was placed in reserve because the ship drew too much water for the action in the water off Copenhagen. As a result Nelson transferred onto the smaller HMS *Elephant* (Teisen 1998, p. 259, Jepsen 2019, pp. 43–44).

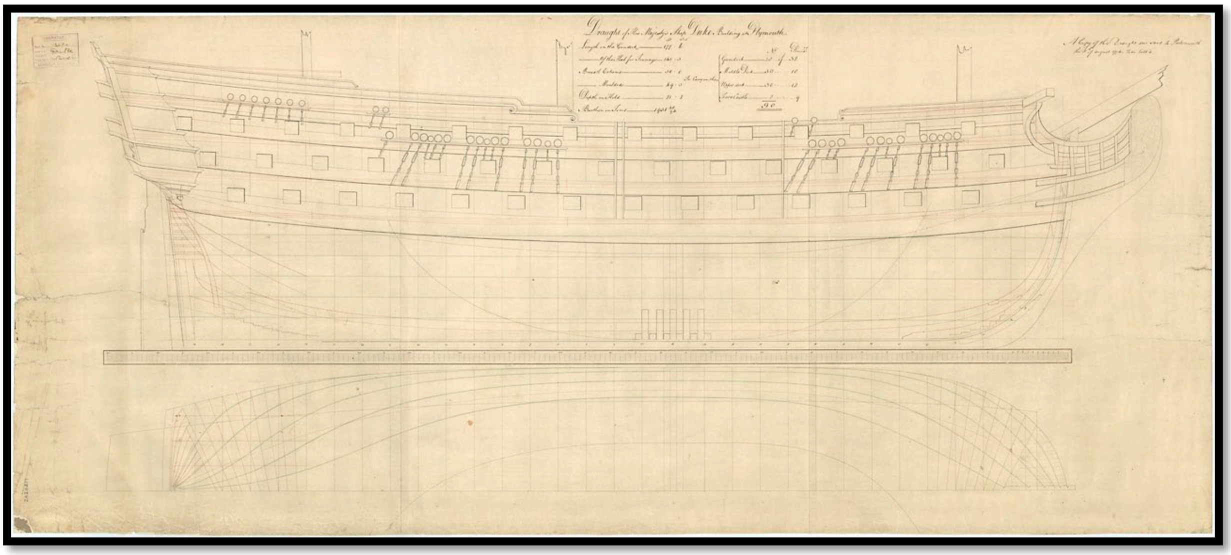

Figure 3.15: The body plan for the Duke class 2nd-rates, which the *St George* was one of four (Image © J1738 NMM, Greenwich, London).

From 1809 up to the loss of the ship, *St George* operated in the Baltic during the war with Denmark (1807-14) as part of the British Baltic squadron and as flag ship to Vice-Admiral Sir James Saumarez's second in command, Rear-Admiral Robert Carthew Reynolds. The roll of *St George* and the other ships within the squadron was to provide escort to convoys of merchant ships. It was vital that Britain maintained control of the Baltic Sea for two very important reasons. First, to protect imports of the Baltic naval stores such as, pitch, timber and hemp and, second, to stop Napoleon building a new fleet by taking control of the region's resources and shipbuilding yards (Rodger 2005, p. 552). *St George's* roll as an escort was extremely important, as Danish waters were rife with licensed privateering. At its peak the Danish-Norwegian privateering fleet consisted of around 600 vessels and brought in 100 million rigsdalers of revenue to the Royal Treasury (Jepsen 2019, p. 120). Privateering was therefore a very serious threat and ships like the *St George* would have been prepared and alert for action during passage through the Baltic Sea. As such, the wreck of the *St George* represents a fully primed and operational warship of the Napoleonic wars.

3.6.3.1 The wrecking and contemporary salvage

Wrecking

On the 24th December during hurricane force winds the *St George* along with the 74-gun *Defence* were blown ashore off the Danish North Sea Coast of Jutland. The *St George* was stranded on a sand bar, which kept its upper parts above the water, but the ferocity of the storm and impact of the waves engulfed those clinging to the ship for survival. Out of the 865 persons on board only 12 made it ashore alive. Local reports record that parts of the ship that washed ashore were salvaged, including a gun on its carriage, but the wreck quickly sank into the sand making it inaccessible to salvors.

Salvage

Salvors with diving equipment returned to the wreck in 1876 and recovered among other things six small guns. The next record of salvage comes from 1904 when a major operation recovers 48 guns. Divers during those operations reported that the upper and middle gundecks had gone but the main gundeck was intact with guns still lashed to the hull at their gun stations. The divers also reported that the orlop was inaccessible as the hatches were full up with sand. The last salvage on site before modern day excavations was in 1940-41 during which copper bolts and a few guns including two brass signal guns were removed (Jepsen 2019, pp. 201–3).

3.6.3.2 Site location, discovery and salvage

The wreck lies 600m off the west coast of Jutland adjacent to the town of Thorsminde (Figure 3.16) (Jepsen 2019, p. 191). It was rediscovered in 1970 by local divers and the wreck is protected by the Danish Museum Act. Following heavy storms in 1980 the site dramatically uncovered exposing the main gundeck. As it lies in only 12m of water, when exposed the remains are extremely vulnerable to high energy wave action.

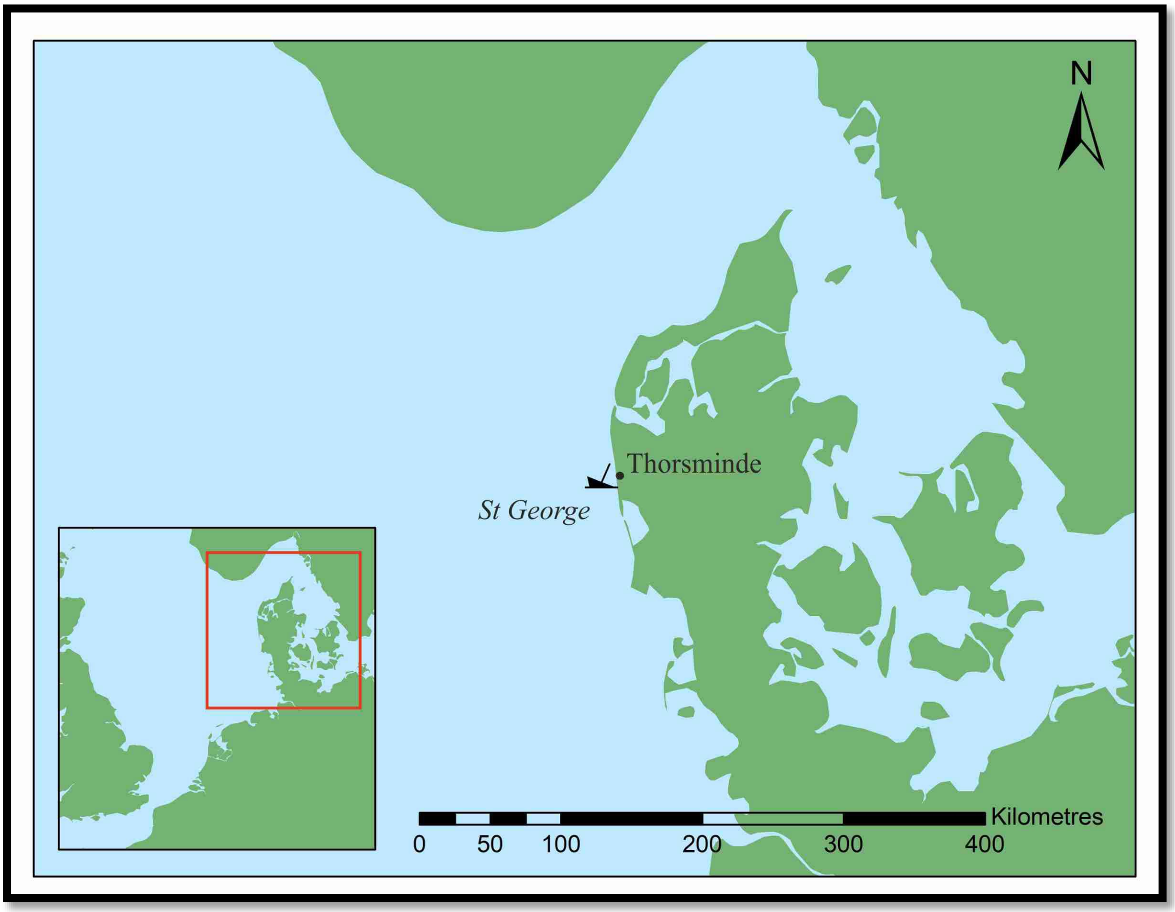

Figure 3.16: Location of the wreck of the *St George* (Image by author).

As a result the Department of Marine Archaeology at the Danish National Museum, alongside the local museum and divers, conducted a series of rescue excavations to recover vulnerable material. The divers initially found the wreck was intact from bow to stern and main gundeck and below. Within two years the deck of the main gundeck was ripped up by the action of the waves exposing the orlop deck (Figure 3.17). At the bow end of the orlop deck the gunner's storeroom became naturally exposed and many gunner's stores were recovered (Teisen 1998, pp. 263–68, Jepsen 2019, pp. 207–16). These stores along with guns and carriages will be the focus of chapter eight.

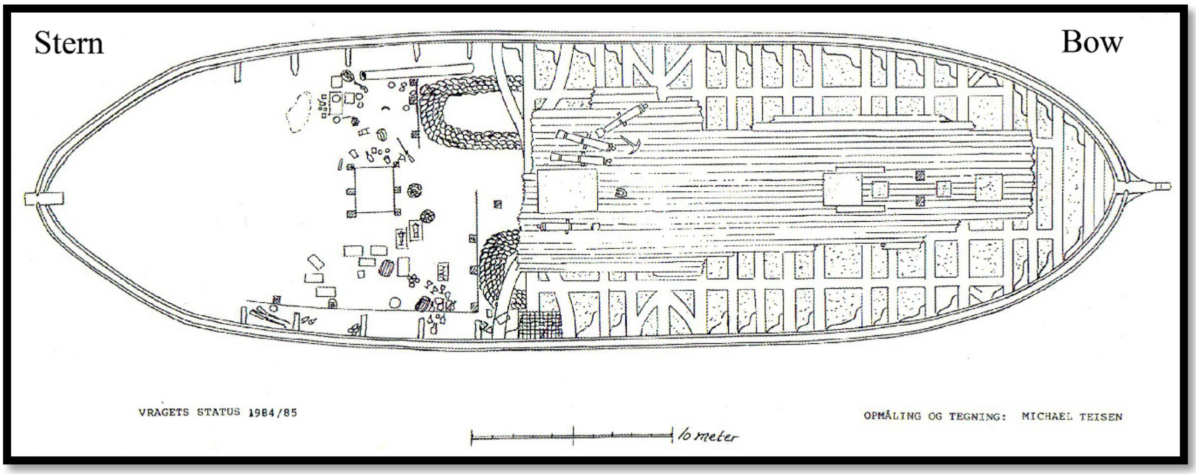

Figure 3.17: The final site plan of the *St George* showing the remains of the gundeck from bow to roughly amidhsips and after the exposed orlop (Jepsen 2019, p. 208).

3.7 SUMMARY

The five main case studies are all heavily armed warships that served during different periods of development in the navy. Following Muckelroy's shipwreck classification each one also represents a '*class 1'* site and thus has a rich source of archaeological material to study, in both the form of hull structures and material culture. These case studies are therefore loaded with information about the people that created, worked and lived on them. As a result they each have the potential to enhance the understanding of the naval gunnery system from the period they represent. Studying these main case studies as a collective, and in conjunction with the historical record and other secondary sites, will enable the tracking of key developments overtime, as well as identifying aspects of the gunnery system that remained the same.

This chapter has also demonstrated the importance of the thorough investigation of the historical record of each case study, as each has proven to have significant records surviving from the time of construction, service and loss, through to contemporary salvage and present-day archaeological investigations. As a consequence, all these phases have had a significant impact on the archaeology we find today and need to be considered when interpreting the naval gunnery system of each site. This chapter, along with the methodology chapter below, reveals the importance of integrating the historical and archaeological sources to produce a higher interpretative value.

Chapter 4 Methodology

The methodological approach for this research is broken down into three stages: desk-based research of the historical record; analysis of existing archaeological collections and publications; and fieldwork, through the collection of new archaeological data. The archaeological and historical records will be integrated to give a more complete interpretation and better understanding of naval gunnery.

4.1 Stage 1 – Desk based

As this study is focused on ships from historical times, written sources have been studied in parallel with the material remains from shipwrecks. These sources include the Ordnance Board and Navy administrative documents, ship's plans, technical drawings of equipment and technical books on the practise of gunnery. There are too many series of documents to mention all of them (although see references for this information), but it is important to describe some of the main examples and how the information in them is important to this research.

4.1.1 *Administrational documentation relating to the Ordnance Board and the Navy*

Documents regarding the Ordnance Board included the WO55 series held at the National Archives. The WO55 series comprises documents relating to the Ordnance Office and War Office: Miscellaneous Entry books and papers from 1568-1923. This series was chosen for this research as it covers all but the first 20 years of the study period and the documents include comprehensive lists of ordnance stores issued to Royal Navy ships of all types. Analysis of these documents identified all types of equipment used in the operation and maintenance of the naval gunnery system on board ship. It also reveals changes, such as when certain equipment was phased out of service and when new equipment was introduced. These inventories were essential in identifying the number and type of equipment issued to each gun and even the types shared between guns, as well as the quantity and types of spare equipment. Projectiles and propellants were listed and even tools and consumables, necessary for maintaining the naval gunnery system. In many cases, inventories for specific vessels exist, as in the case of the *London* (TNA WO55/1667). In this case the inventory identified exactly the type and quantity of guns and gunnery stores that were issued to the ship, only days before it was lost. This enables an exact comparison between the historical and archaeological record.

As mentioned above, the Board of Ordnance supplied the Navy with guns and the gun's equipment, stores, ammunition and propellant (Robertson 1968, p. 145, Tomlinson 1979, p. 103, Lavery 1984, p. 146). However, all of this had to be made and supplied to the Board of Ordnance by individual contractors and businesses. The bills for this contract work for supplying the Board of Ordnance is found in the WO51 series held at the National Archives. This series contains entry books and bills from 1630-1806. Although not detailed, these documents are useful in that they provide some evidence on how certain pieces of equipment were made and by whom.

These inventories and bill books, however, do not identify how the equipment was operated and maintained on board ship. To establish a better understanding of this, the Council of State Papers Domestic (CSPD) and several Admiralty (ADM) administrative documents were investigated. The CSPD are made up of a range of document types including naval affairs from the time of Elizabeth I through to George III. The ADM documents consist of a variety of documents relating to the Navy Board, ship's logs and miscellaneous letters. Hidden in these documents are accounts and descriptions from people that administered and operated the naval gunnery system. They provide personal accounts on how certain pieces of equipment functioned, often highlighting issues and problems. These documents provide constructional and functional details that the inventories do not show.

4.1.2 *History and background of the main case studies*

Archival research of the main case studies is essential to build a ship's life story from conception and use through to their loss and salvage. By researching documents relating to the ship's construction, repairs, rebuilds, service career and loss, it is possible to construct a more complete picture of the ship. This is important as all of these events during the life and loss of the ship had a potential direct or indirect effect on the naval gunnery system and those that operated it. It is vital to understand changes that may have occurred during the ship's service, as well as interference caused by the wrecking and contemporary salvage, as this will influence how we interpret the archaeology today.

The quantity and type of historical documents surviving for each ship does differ. In general, greater records tend to survive for the later ships, such as the *St George,* compared to ships from earlier periods. One reason for this was the naval administration was simply more organised and efficient from the mid-eighteenth century, and more records were created and survive. However, because the *Mary Rose, London* and the *Invincible* were prestigious ships of their time, records for them are quite considerable. It is extremely fortunate for archaeologists and historians that these ships were wrecked and subsequently rediscovered, with their remains allowing archaeologists to challenge the historical record.

Many primary sources specifically relating to the main case studies and other ships have been consulted at the National Maritime Museum (NMM), the National Archives (TNA), the British Library (BL), the Royal Collections Trust (RCT), the Priddys Hard Archive, at the Hampshire County Council Archives (HCCA), the Biblioteque National de France (BNF) and the Museé National de la Marine (MNM). Where possible, and if they survive, the following sources will be looked at: ship's plans or drafts, building and rebuilding reports, ship's logs and inventories of stores. Fortunately, significant research has been conducted on the main case studies providing numerous references. The following of these references has illuminated the historical pathways of research, but, more than this, has led to the discovery of further sources that would not have been found otherwise. For this research, along with the archaeology: the historical record of the *Mary Rose* is well documented in several publications (McKee 1973, Rule 1982, Marsden 2003, 2009, Hildred 2011). The *London* has been well researched by Fox (Fox 2011) and Pascoe (Pascoe 2017a). The *Hazardous* has had considerable research conducted by the Hazardous project team (Owen 1988, 1991). The history of the *Invincible* has been well documented by Lavery (Lavery 1988) and Bingeman (Bingeman 2010). Numerous archaeological reports have been produced by Kevin Camidge and CISMAS for the *Colossus* and, although unpublished, they are all available to download from the CISMAS website.[1] There have also been articles and booklets produced giving an overview of archaeological investigations (Birchall 1998, Cornwall and Isles of Scilly Maritime Archaeology Society 2006). In 2019 a publication including the history and wrecking of the *St George* was translated and published from Danish to English (Jepsen 2019). The published works will therefore act as the starting point on a long and winding path of historical and archaeological detective work.

[1] https://cismas.org.uk/resources/ checked 21/12/2021

4.1.3 *Ship's plans and iconographic evidence*

To help understand how the gunnery system was maintained and supplied on-board ship, an understanding of the internal layout of the ships is necessary. The internal plans of ships often show, with annotations, where storerooms, cabins and compartments were placed, with those relating to the storage and supply of gunnery equipment, munitions and propellant often clearly labelled. Analysing plans of ships from across the period identifies where gunnery related material was kept, but also changes in their location throughout time. Understanding the distribution of certain equipment and materials on board a ship not only helps understand how the gunnery system was maintained and supplied but can also help identify areas of a wreck site. Through identifying the distribution of artefacts on a wreck site it is possible to understand which part of the ship is represented on the seabed. This is especially useful when only non-intrusive investigations are permitted, and the typology of surface artefacts identifies areas of the ship present or buried beneath the surface of the seabed.

Iconographic sources were also essential in this research. Contemporary illustrations, albeit with an artistic hand, often show the details that are missing from written sources. In many instances it is possible to see gunnery objects, such as guns and carriages, in association with their location on the ship and with the crew that operated them. Therefore, the iconographic evidence gives context to the objects, which is critical in understanding how the guns were operated. Through the analysis of the iconographic record it is also possible to track changes in designs and the introduction or loss of certain pieces of equipment. However, as with all art, it is an individual's impression of the subject and therefore accuracy may be compromised for the sake of a good picture. The archaeology can be used to challenge or critique the iconographic evidence.

4.1.4 *Contemporary technical writings on gunnery*

Lastly, this research studied many contemporary writings on the art, science and practice of gunnery from the 16th century and into the 19th century. These writings came in the form of technical books written by experienced gunners. These books cover the principles of gunnery; propellant; projectiles; dissertations of cannon; their uses, sizes and methods of mounting and operating. Up to the late 16th century the master gunners were well paid and high status individuals (Lavery 1984, p. 147) and the practice of gunnery was very much perceived as a science; the content in these earlier works are heavily mathematical and largely based on theory. This resulted in very idealistic practices of gunnery - of how it should be rather than how it actually was (Martin 1984, p. 235).

However, as we progress through the centuries the master gunner loses status and low-ranking officers take over the duty of commanding the firing of the guns. In later gunnery books the emphasis is more on the practical knowledge of gunnery; they are more akin to working manuals describing how to operate and maintain the gunnery system and less about the science behind the guns. They describe in detail the best practice for operating and maintaining the gunnery system, often providing advice or tips for how certain pieces of equipment should be made to ensure effective use. This information is extremely useful in assisting in the interpretation of the archaeological data and key to understanding how objects functioned. Although the main weapon, the SMBL gun, does not change from the time of the *Mary Rose* through to the *St George,* the way the weapon system was operated and maintained does. These manuals were extremely useful in tracking and identifying these periods of change. Although, one has to be aware that some of the manuals were written by ex-practitioners often writing about gunnery when they were in service, rather than at the time the books were published.

4.2 Stage 2 – Analysis of existing archaeological collections, records and publications

For all those interested in the maritime archaeology of the Royal Navy there have been over 1,700 Royal Navy losses recorded around the world between 1650-1859 (D.Hepper 1994). There is, therefore, a wealth of potential in the archaeology of the Royal Navy that will only grow as more shipwrecks are discovered. Concentrating on the known resource, the UK alone currently has 21 designated wrecks out of 72 related to the sailing ships of the Royal Navy (Table 4.1). This study has been made possible, in part, but not exclusively, due the work conducted on those 21 shipwrecks over the last forty-six years. With the exception of the *St George*, the other four main case studies are all protected wrecks in the UK. In addition, several others but to a lesser extent feature in this study.

Some of this work has been extensive, such as the *Mary Rose,* where the remains of the ship were lifted along with its contents (Rule 1982, Marsden 2003, 2009, Hildred 2011). This has provided an incredible archaeological resource for study, combining intrinsic and extrinsic information. In most cases, however, shipwreck sites are only partially investigated, mainly due to the high cost of underwater work and the conservation of waterlogged material. This has led to a more cautious approach to underwater investigations. Intrusive work is now more strategic, aimed at answering specific research aims or prioritising the most vulnerable areas of a site. The result of this has been the partial rather than full excavation of sites, the surface recovery of exposed and at-risk objects, or merely the survey of exposed features. Each of these activities provide different levels of information and there is high potential for new evidence to come to light in the future. Due to the incomplete nature of most assemblages the researcher must leave the door open for re-examination and interpretation should new information arise.

In the process of conducting this research, several collections of gunnery equipment recovered from shipwrecks were re-examined alongside publications, archaeological reports and diver's logs. These include two of the main case studies in this research, the *Colossus* and the *St George*, which cap the end of the period under investigation. It must also be noted that with the cases of the *Hazardous* and the *Invincible,* there were previous investigations too, which led to the recovery of objects and records. These earlier assemblages and records were studied in conjunction with the new data and material recovered from the sites.

In some cases, single artefacts or assemblages have come from terrestrial archaeological sites or survived in historical buildings. In these cases, the original contexts of the objects have been lost, but their style and form lead to the identification of a particular period. It is then possible to compare them alongside the evidence from known and dated shipwrecks. An example of this is a *c.*17th century ships gun carriage and gun found in the curfew Tower at Windsor castle (Smith 1993), which directly comparable to the carriages recovered from the Duart Point wreck (Martin 2004, 2017), the *London* (Pascoe 2017a) and the *Stirling Castle* (McElvogue 2008).

Ship	Period	Type of vessel	Year of designation
Grace Dieu	1436	Clinker carrack	1974
Holigost	1422	Clinker carrack	2016
Mary Rose	1545	Carrack	1974
Duart Point Wreck	1653	Small warship	1992
London	1665	2nd rate	2007

Royal Yacht Mary	1675	A Royal Yacht	1974
Anne	1690	3rd rate	1974
Dartmouth	1690	5th Rate	1974
Coronation	1691	2nd rate	1978
Northumberland	1703	3rd rate	1981
Stirling Castle	1703	3rd rate	1980
Restoration	1703	3rd rate	1981
Hazardous	1706	4th rate	1986
Association	1707	2nd rate	2016
Eagle	1707	3rd rate	1975
Royal Anne Galley	1721	5th rate	1993
HMS Assurance	1753	5th rate	1974
HMS Invincible	1758	3rd rate	1980
HMS Colossus	1798	3rd rate	1975
HMS Pomone	1811	Frigate	1974

Table 4.1: List of protected sites that are Royal ships or ships of the Royal Navy.

4.3 Stage 3 – Fieldwork

Fieldwork has been critical for this research as it has provided new data for analysis and interpretation. As briefly mentioned above it is important to understand how the data was collected, as different methods have provided varying levels of information. The fieldwork data were collected from several historic wrecks in the UK, three of these, the *London*, the *Hazardous*, and the *Invincible,* are three of the five main case studies in this research and the methods of data collection will be described in detail in sections 4.3.1-3 below. With the case of the *Colossus* the majority of the information presented came from analysis of previous work conducted by Kevin Camidge and the CISMAS group, although some images and interpretations have come from personal experience of diving with CISMAS during their 2014 fieldwork project.

These sites are all protected by the Protection of Wrecks Act 1973, which controls the activities that can be undertaken on the sites (Historic England 2015, p. 3). This protection means all work must be licensed and the type of work one can do will be framed by conditions that are relevant to proposed activities (Historic England 2015, p. 4). The type of work permitted directly effects the archaeological data that can be collected.

There are three main activities or categories of work a license can specify including, but not limited to: survey, surface recovery and excavation. The survey work allows one to record only the exposed elements of the site with no intrusive activities permitted. This type of information has its limitations, such as the degradation of exposed archaeological features through biological and physical decay. This means the original surfaces, which, for example, could have shown tool and carpenters marks, are often lost. Understanding contexts is also limited as much of the site can be buried and therefore out of view.

A license that includes surface recovery enables the recovery of artefacts that have become exposed and under threat from the physical and biological environment (Historic England 2015, p. 16). The main issue here is understanding the context that the artefact came from, as this is usually lacking. In dynamic environments, as often is the case with shipwrecks, light or fragile artefacts, once uncovered, can move along the seabed. It is therefore not always possible to fully understand where these artefacts originally came from within the ship. The other issue is that if the artefact has been exposed for a prolonged period of time, then the artefact's surface will have deteriorated and constructional and use marks may have been lost.

Finally, a license that includes excavation enables the recording and recovery of well-preserved material from within the original context of the ship. In these cases, the greatest amount of information can be gleaned from both the artefacts and their location in relation to other objects and the wreck. This provides the critical information for understanding how they were used and organised by the people on board. Studying the finds and their spatial distribution within the wreck is a crucial way to determine shipboard culture and behaviour (Djindjian 2000, Adams 2013, Rönnby 2013a).

In the cases of the *London* and the *Invincible*, the majority of data included in this research was recorded during excavations of strategically placed trenches within surviving hull structure (Cotswold Archaeology 2014, 2015, 2016). However, some finds have been recovered as exposed surface finds either prior to or post excavation. With the case of the *Hazardous* wreck, small-scale excavation has occurred but most of the material relating to gunnery has come from either in-situ observations or the recovery of surface finds over several years. The layout out of the surviving wreck structure of the *Hazardous* is clearly discernible, so it is possible to have a good understanding of the locations of these artefacts within the layout of the ship and therefore to have reasonable understanding of their context. However, this may not be the case with all artefacts, especially small and lightweight objects.

For this research, primary archaeological data has been collected from three of the five main case studies: the *London*, the *Hazardous* and the *Invincible*. In the case of the *London* and the *Invincible* the majority of the recovered artefact assemblages have been recovered during excavations. This has led to understanding the relationship between the objects and their place on the ship. With this high level of information, it is possible to give the objects a cultural context and identify probable routine behaviour but also, most noticeably with the *London*, the activity and behaviour of the crew at the moment the ship blew up.

It is not just the type of license that directly effects the level of archaeological information that can be collected from a site. The physical environment of a site, for example, has a huge impact on the quality and quantity of archaeological data that can be collected, and each site's environment is very different. The section below will discuss the variables that impact data collection during fieldwork.

4.3.1 *Underwater data collection methods*

To work underwater on sites in the UK a robust and flexible methodology is necessary. Thus, a variety of underwater excavation and survey techniques were used depending on the following variables:

1. Fieldwork budgets;
2. General environmental site conditions (tides, currents, winds, depth, underwater visibility) that affect data collection during fieldwork;
3. Weather conditions during fieldwork that allowed or restricted data collection;
4. Physical condition of the wreck/state of preservation and survival;
5. Time on site, which is affected by all of the above.

All of the above variables differed for each site and determined the methods by which the archaeological data were recorded. The fieldwork methods will therefore be broken down by site.

4.3.2 *The London fieldwork methodology*

The *London* wreck was excavated as part of a project funded by Historic England (HE) and managed by Cotswold Archaeology (CA). It was a medium budget project aimed at recovering and recording material at risk. The author was the site's nominated archaeologist and was sub-contracted by CA as the lead archaeologist for the excavation. The excavation was conducted over 13 days between May and August 2014, nine days between May and June 2015 and six days in June 2016 (Cotswold Archaeology 2014, 2015, 2016).

The wreck is located in a precarious location in the Thames Estuary, situated on the edge of the main shipping channel in and out of London. It lies at a depth of 20m at high tide. Tides and underwater currents are extremely strong and underwater visibility is poor due to the turbidity of the water. Due to the big tides and strong currents, time on the seabed is limited to 90 minutes on a flood tide and 60 minutes on the ebb tide (Cotswold Archaeology 2014, 2015, 2016, Pascoe 2017b). Underwater visibility is generally poor during both states of the tide, but worse on the ebb, when the flow of water is coming from up-river. On the ebb tide the underwater visibility ranges from 0-10cm. On the flood tide underwater visibility is better ranging from 10-50cm with a high-powered torch, with the best visibility coming at the top of the flood tide, when cleaner water flows in from the open sea.

The flood tides were chosen to conduct excavation and survey work during the project. This limited work to two 90-minute windows per day, thus allowing three hours of work-time each day on the seabed. Due to these time constraints, and poor visibility underwater, recording methods were limited.

As well as the artefacts recovered during the excavation this research has analysed artefacts that have been recovered from the wreck since the excavations. The Licensee of the wreck, Steve Ellis, recovered this material in 2018 under a license that includes survey and surface recovery. The artefacts were all recovered by hand during non-commercial diving operations. These artefacts were brought to the author for analysis and conservation at the BU and MAST conservation facility in Poole.

Diving

All diving work was undertaken in adherence to the Diving at Work Regulations 1997 (DWR97) and following the guidance laid out in the Scientific and Archaeological Diving

Projects Approved Code of Practice (ACoP). Dives were carried out using SCUBA with full-face masks (FFM) with through-water communications and monitored by a diving supervisor on the surface. All diving was undertaken using air with a single main 15 litre cylinder with sufficient bailout in the form of three litre pony cylinder (Cotswold Archaeology 2014, 2015, 2016). Divers worked in buddy pairs, acting as in-water standbys for each other. Each diver would have approximately 45 minutes on the seabed before allowing enough air to return safely to the surface.

Diving vessel

Diving operations were conducted from the Dive Support Vessel (DSV), *Jumbo*, which was a 16m long barge. The DSV was moored over the site on a two-point mooring system 24 hours a day. This type of vessel has the capability of lifting heavy objects via a hydraulically operated crane (Cotswold Archaeology 2016, p. 13). It also has the deck space to deal with tools and equipment as well as for finds processing. Both are essential for excavation work that requires the recovery of large and multiple artefacts.

Excavation

Excavation was primarily carried-out with the use of 4” airlifts powered by a road compressor on the deck of the DSV. Divers used additional hand tools, such as trowels and spades, when required. A baseline was established on the northern edge of the site and a trench located on the edge of the structure of the main gundeck at the position of a partially exposed gun carriage. The carriage was situated adjacent to a gunport. The location of the trench was positioned by trilateration from known control points on the wreck (Cotswold Archaeology 2016, p. 13).

Positioning of artefacts

The location of the trench was then positioned on the multibeam bathymetry and georeferenced in ArcGIS. A georeferenced grid system of 1 x 1m squares was placed over the bathymetry and this enabled recovered artefacts to be positioned in relation to a grid square (Cotswold Archaeology 2014, 2015, 2016). The distribution of artefacts were also recorded in relation to the ship’s structure, which was key to the interpretation of the recovered assemblage and how it enhanced the understanding of maintaining the naval gunnery at this time.

Recording Methods
Due to the poor visibility and lack of bottom time, it was not practical to make measured drawings or sketches. Instead, a GoPro Hero 4 with an Inon semi-fisheye lens and two high-powered video lights was used to film the trench at the end of the last dive of each tide. This coincided with the best underwater visibility and enabled a visual recording of artefacts in-situ and in relation to their position in the trench and the vessel's structure (Figure 4.1) (Cotswold Archaeology 2014, 2015, 2016). During post-processing of the footage, still images were captured from the video in Adobe Premier, an editing software.

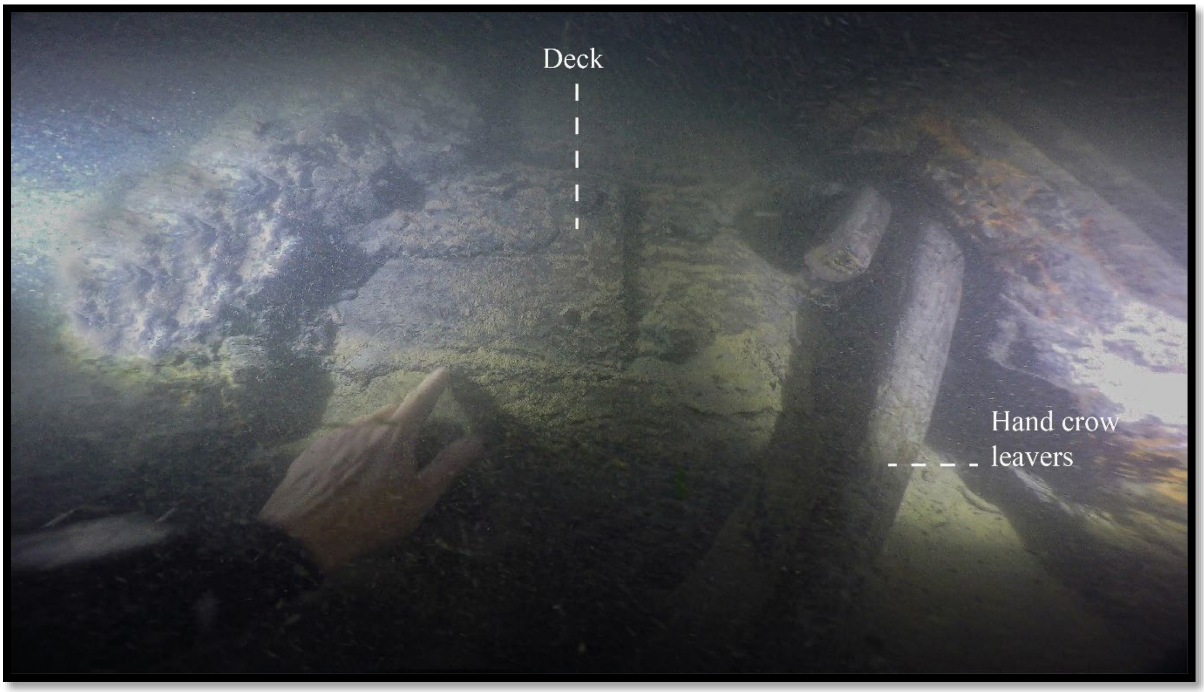

Figure 4.1; Image demonstrating the diver pointing at the corking between the seams of the deck planks, while holding the camera in the other hand. This is a still image grabbed from video footage captured at the end of the dive (Image captured and produced by author).

4.3.3 *The Hazardous fieldwork methodology*

Fieldwork relevant to this section begins in 2014 when the author became the nominated archaeologist for the site. Since then archaeological data has been collected from the site through in-situ observations, recovery of at-risk surface artefacts and excavation. However, the data relating to this research has come mainly from in-situ observations, recovery of surface artefacts and archaeological records and artefacts from investigations pre-2014. The *Hazardous* project team are all volunteers and as such all work on site is purely voluntary. The team dive are on site throughout the year when weather and time permits. There was no formal project schedule.

The wreck is located in eight metres of water, 800m off the beach in Bracklesham Bay (Owen 1988, p. 285). The site can be dived during any state of the tide, during spring or neap tides. The major factor that affects work on site is underwater visibility. Due to the shallow nature of the site and its location in the bay, close to shore, seabed sediments get stirred up during periods of bad weather. This increases the turbidity of the water reducing underwater visibility. Therefore, meaningful diving investigations can only take place during periods of calm weather when the underwater visibility can range from 1-5m.

Diving

As all work on site is voluntary, diving practices are under a recreational auspice. Dives are carried out using recreational SCUBA equipment. Divers work in buddy pairs and, due to the shallow nature of the site and slight underwater currents, can work between 60-120 minutes per dive.

Diving vessel

Diving operations were conducted by the DSV, *Blue Meanie*, which was a 5m long RIB. The DSV moors over the site on either a single or double mooring. The size of the DSV does limit the work that can be conducted and, more significantly, the size of artefacts that can be recovered. As a result, the size of recovered artefacts is determined by what a diver can recover by hand. There is therefore no capability to recover objects such as gun carriages or guns.

Positioning of artefacts

The main site of *Hazardous* has a network of datum points installed. Recovered artefacts were positioned through trilateration (Figure 4.2). The whole of the main site was recorded photogrammetrically in 2017 and again in 2019. The results of the surveys have been scaled and georeferenced in ArcGIS in relation to 2014 multibeam bathymetry data. The position of large artefacts and features have therefore been given an exact position in time and space.

There are two further areas of wreckage associated with the *Hazardous* to the north and south of the main wreck structure. These sites are predominantly made-up of guns and iron shot and are known as the 2014 and 2019 gun sites due to the year of their discovery. In 2019 the sites were recorded photogrammetrically and the results were scaled and georeferenced in ArcGIS. In 2020 further seabed sediment movement revealed the 2019 gun site was more extensive, with further dense scatters of iron and lead shot, domestic items as well as ship's money lying exposed on the seabed. This area was surveyed and results merged with the 2019 plan.

Due to the complete coverage of the photogrammetry surveys it was possible to identify large clusters of iron shot and their relationship with the location of the guns. The photogrammetry results are a useful analytical tool and therefore valuable in both understanding the wrecking event and enhancing the understanding of where shot was distributed on the ship.

Figure 4.2: Photo showing Dr Rachel Bynoe recording the position of an artefact in relation to one of a network of datum points installed on the site (Photo by author).

Recording methods

Since 2017, photogrammetry has been the preferred method used to survey the site. The method of photogrammetry is a rapid recording technique, which can be regularly repeated on a shallow site, such as the *Hazardous*. It has been used as a method to monitor the physical changes occurring to the site but also to record the location of artefacts and features in relation to the wreck. The results have been used in this research to illustrate and understand the distribution of gunnery equipment in relation to the wreck. In addition, finds were photographed and filmed in-situ with a Gopro Hero 4 and 6 with an Inon semi-fisheye lens and video lights prior to recovery.

As photogrammetry was used on other sites, the methodology of capturing and processing the data will be described in section 4.3.5.

4.3.4 *The Invincible fieldwork methodology*

Archaeological data from the *Invincible* has come from two phases of investigations. The first was by a team led by John Bingeman between 1980 and 2010 (Bingeman 1985, 2010). The material from this phase has been re-analysed and methods covered in section 4.2 and results included in chapter 7. The second phase started when the author took over the License of the site from John in 2010. Between 2010 and May 2017 archaeological data was gathered from in-situ observations and recovery of exposed surface artefacts (Pascoe Archaeology 2014, 2015, 2017a). However, the majority of new archaeological data, directly relating to this thesis, has come from excavations between May 2017 and September 2019. This was a large-scale excavation, with a large budget, funded through the Libor and the Heritage Lottery. The project was a partnership between MAST, BU and the NMRN. MAST managed the project and BU were contracted to conduct the Archaeological and conservation work. All the archaeological material will be deposited with the museum.

The budget enabled three periods of excavation from 2017 - 2019. The first period was from 1st June to the 30th June 2017; the second from the 4th May to the 22nd June 2018; and the third from the 27th April to the 22nd of June 2019. The wreck of *Invincible* is located on a sand bank in the eastern Solent in 7-9m of water, depending on the state of the tide. During periods of neap tides diving is possible for 8-10 hours during a 12-hour working day, leaving an hour of transit time at the beginning and the end of the day. Diving time is steadily reduced approaching spring tides until only 1-2 hours are achievable during each tide at the top of springs. Between April and July underwater visibility can range from 1-5m depending on weather conditions and seasonal plankton blooms, the latter being the greatest hindrance. In general, site conditions and underwater visibility were good, which led to high productivity in terms of excavation and survey work.

Diving

All diving works were undertaken in adherence to the Diving at Work Regulations 1997 (DWR97) and following the guidance laid out in the Scientific and Archaeological Diving Projects Approved Code of Practice (ACoP). Dives were carried out using SCUBA with full-face masks (FFM) with through-water communications, monitored by a diving supervisor on the surface. All diving was undertaken using air with independently operated twin main 15 litre cylinders. A 50 bar reserve of air was kept in both cylinders on return to the surface and in case of an emergency. Divers worked in buddy pairs, acting as in-water standbys for each other.

Diving vessel
Diving operations were conducted from the Dive Support Vessel (DSV), *Avon*, which is a 25m long barge. The DSV was moored over the site on a two-point mooring system for daylight operations. This type of vessel has the capability of lifting heavy objects via a hydraulically operated crane. It also has the deck space to deal with tools and equipment as well as for finds processing. Both are essential for excavation work that requires the recovery of large and multiple artefacts.

Excavation
Excavation was conducted with the use of a combination of 6-inch and 4-inch airlift powered by a road compressor from the deck of the DSV. The 6-inch airlifts were primarily used to remove overburden and the 4-inch airlifts used when the archaeological layers were encountered. A network of 3 x 3 m scaffolding grids were installed over the excavation areas to enable each diver to excavate within a designated grid or section of a grid (Figure 4.3).

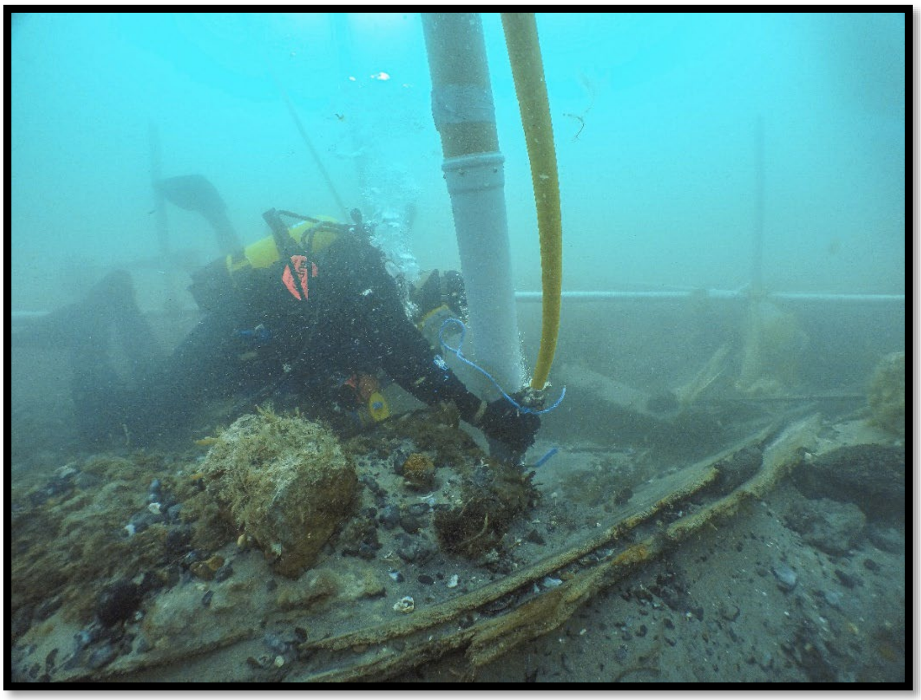

Figure 4.3: Photo showing diver excavating within the scaffold grid using a 4-inch airlift (Photo by author).

Three out of five trenches were strategically placed over areas of the site that had potential structures and material relating to gunnery. These were as follows:

- Trench 1 was located at the port bow and extended from the gundeck and down through the orlop and hold. The gundeck had the partial survival of the two forward most gunports. These gunports and fittings around the gunports provide evidence of securing the guns. Below the gundeck was the partial remains of the orlop, where the gunner's storeroom was located. Spare gun equipment was stored here and therefore provides evidence of supplying and maintaining the gunnery system. Below the orlop was the forward magazine where gunpowder was stored and transferred into cartridge cases. This area, and the material found here, revealed critical evidence for the storage of gunpowder and supply of powder cartridges to the guns. Forward of the magazine was another store, which was also directly below the gunner's store on the orlop deck. This store area contained more spare gun equipment and its recording is critical in understanding the storage and organisation of gunnery equipment.
- Trench 2 was located at an area of exposed round shot. Excavation of this area provides evidence of the storage and supply of shot.
- Trench 3 was located at the stern end of the port side and extended down from the gundeck to the keel. The last two gunports were revealed here, identifying methods of securing the guns.

Positioning of artefacts

The general positioning of artefacts was performed through a galvanised grid system that was constructed over the excavation areas. The grid was composed of 3x3m squares, with each square divided into nine 1 x 1m squares. The corners of the grid system were positioned in relation to known datum points on the site. These positions were plotted into ArcGIS and overlain onto a georeferenced multibeam bathymetry image of the site. Recovered artefacts were assigned to an individual 1 x 1m square within the 3 x 3m square (BU 2017, 69). Where there were groups of artefacts or multiple layers of artefacts photogrammetry surveys were performed for each context. This was critical for recording the relationship between the gunnery objects and their context within the ship.

Recording methods

Photogrammetry was the primary recording method to record the structure of the ship and artefacts in-situ (see section 4.3.5 for photogrammetry methodology). The results of the photogrammetry are used in this thesis to illustrate the location of gunnery equipment in relation to their position on the ship. This has been essential in showing the distribution of gunnery equipment within the ship and how this enhances the understanding of the organisation and maintenance of the naval gunnery system on a Georgian warship. In addition, Digital SLRs and Gopro Hero 4-9s were used to record archaeological features and artefacts in-situ.

4.3.5 *Photogrammetry Recording of Sites*

Photogrammetry is a survey technique for producing accurate measurements by using digital photo imagery to locate features on a surface. The result produces the coordinate (x,y and z) position of a particular point, creating a planimetric feature, or graphic representation of the terrain on a cartesian plane (Schenk 2005,4; WYTOD 2013,3; Ortiz 2019, 80).

Photogrammetry presents the advantage and flexibility of building multi-purpose datasets, while also recovering a higher level of detail in short periods of time and over large areas (F. Sulas and M. Madella 2012, F. Galeazzi 2016). Unlike 2D photo-mosaic survey, this method adds a third dimension (height) to the formula, allowing the accurate capture of archaeological features. Using the parallax principle, photogrammetry adds a stereoscopic perspective to the data based on multiple shot overlapping. This creates a 3D mesh, which can be manipulated so that surveyed features are seen from all angles.

The majority of the photogrammetry surveys conducted during the fieldwork phases of this research were carried out by the author using a range of GoPros from Hero 4 - 9, with an Inon semi-fisheye lens. The camera was set to time lapse mode to take a photo every second. During the survey the author would swim a series of systematic and overlapping lines over the archaeological features using baselines or the scaffolding grids for orientation. Each horizontal scaffold pole had a 1 m black strip painted at its centre to enable the surveyor to easily divide the grid and swim in straight lines. The 1 m black strip was also useful as a scale to aid post processing (Figure 4.4).

A series of images, taken as stills, are batch processed to correct colours and make any required adjustments. The images are adjusted as a batch to ensure consistency. Once adjusted the images are processed using Agisoft Metashape to create a range of products including point clouds, surface models (meshed point cloud) and photorealistic models. The models can be further processed in software such as Autodesk 3D Studio Max where lighting effects can be applied to further enhance the model.

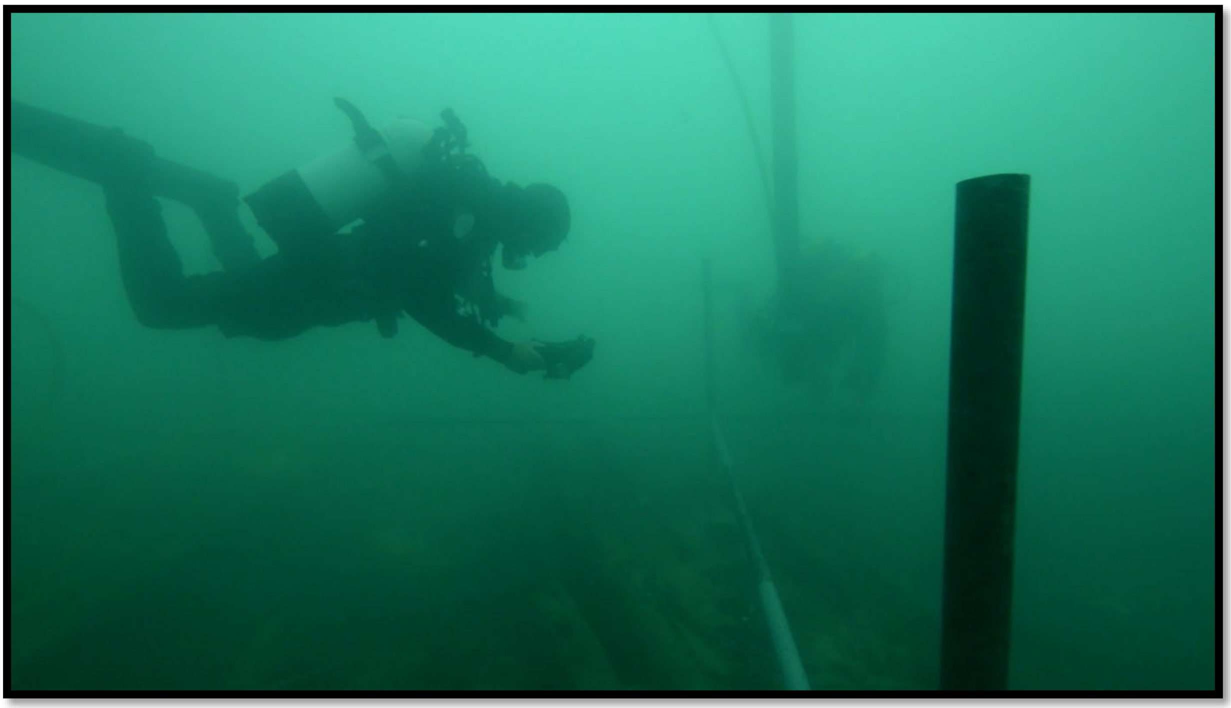

Figure 4.4: A image of the author conducting a photogrammetry survey on the wreck of *Invincible*. (Image by Michael Pitts).

4.3.6 *Artefact recording and analysis*

Wet artefacts

Wet artefacts came from three of the main case studies, the *London,* the *Hazardous* and the *Invincible* and all were treated in accordance with the CIfA *Standard and Guidance for the Collection, Documentation, Conservation and Research of Archaeological Materials* (CIfA 2014).

The artefacts were stored in a number of different containers or within plastic bags within larger containers. All were clearly labelled and the majority were in good condition reflecting the anoxic burial environments that they were recovered from. On some artefacts there was some mechanical erosion evident and loss of surface detail due to the activity of marine borers. Any metal fittings had been subject to corrosion, leaving staining within the wood adjacent to the original fitting. Any concretion still adhering to the objects was left and no attempts were made to clean iron stained surfaces. In the case of the *London,* and following recommendations by the author, several artefacts were radiographed by Historic England's lead conservator, Angela Middleton, at Historic England's conservation laboratory at Fort Cumberland. The results of the radiographs were made available to the author for analysis and identify internal structures of objects which are obscured by concretion or the outer surfaces of the objects themselves. The radiographs can also identify constructional details such as fastenings or the cavities made by fastenings. This type of information is useful in understanding how objects were made.

The artefacts are presented in this research by the site name followed by the object name and unique artefact number. A combination of measured sketches and digital photographs were made of each object and in some cases photogrammetric models.

4.4 Summary

This chapter, in conjunction with the previous case study chapter, have demonstrated that there is a plethora of historical material including primary sources, contemporary literature and iconography, which provide both general information relating to gunnery and aspects of gunnery specific to individual ships. These chapters have also shown that there is a rich archaeological record from past and new archaeological investigations. This has led to the reanalysis of existing material and the collection of new, thorough underwater fieldwork. The methodologies for the latter have varied for each site due to the differences in the underwater environments and conditions, fieldwork budgets and licensable activities. The methodological approach for this research has followed Adam's and Rönnby's example and is based on the integration of archaeological and historical studies, where the source material is combined to produce new insights and a greater understanding of English/British naval gunnery from a technological and cultural perspective (Adams 2013, p. 48, Rönnby 2013b, p. 16). The archaeology will not be merely used to compliment the written sources but used to critically examine the periods of the wrecks and established historical myths and truths (Rönnby 2013b, p. 19).

The five main case studies introduced in chapter three, and which make up the next four chapters, will reveal an incredibly rich archaeological resource through the preservation of coherent structure, containing an abundance of material culture relating to all facets of the naval gunnery system. The analysis of the objects alongside the historical record will first identify the technology that existed at a particular period and the changes over time. Second, the location of objects and their relation to other objects, containers, storage areas and gun bays and decks within the ship, alongside unique details of construction and use embedded in the objects will identify the skills, behaviours and routines of the people that made and operated the gunnery system (Adams 2013, Hocker 2013, Rönnby 2013). This will lead to a better understanding of shipboard cultures and attributes such as organisation, discipline and professionalism, and whether these change over time.

Chapter 5 The *London* (1656-1665)

5.1 Introduction to the *London* results

This chapter will present the archaeological, historical and iconographic evidence relating to the wreck of the *London* with supporting evidence from other sites of wrecks that served up to the end of the third quarter of the 17th century. With the case of the *London* it is extremely fortunate that a document, known as the Chatham ledger survives, which is an inventory of guns, munitions and ordnance stores (TNA WO55/1667). It shows both the returns to store, i.e. what came out of the ship when it came into dry dock, and then the stores re-issued, i.e. the stores that were put back into the ship. The ledger includes records from the start of the *London's* 1664 commission, which allows us to see the quantity of stores and munitions used between then and the end of the commission in February 1665. This is valuable information as it provides an understanding of how involved the ship was in operations and in practicing with the great guns during that period. This written record allows for a direct comparison with the archaeological remains found on, and recovered from, the wreck. The Chatham ledger provides both the historian and archaeologist with an accurate source of information regarding the stores that went onto the ship and how much was used between commissions. So, we know much of what should be on board but understanding the relationship between the stores and how they were organised, used and distributed around the ship comes predominantly from the archaeology.

In addition to the ledger there is contemporary pictorial evidence of the *London* in the form of section drawings of the bow, amidships and stern sections of the hull (RCIN 1047387). These drawings also include depictions of guns, carriages and other equipment, which allows for a direct comparison with the archaeology found and recovered from the wreck.

5.2 Introduction to the 2014- present site investigations

This section contains the results from three relatively short excavation seasons between 2014 and 2016 and, in addition, surface recoveries and observations from 2017 onwards from Site 2 of the *London*. During the excavation period four trenches were excavated across the width of the site (Figure 5.1). These trenches identified that Site 2 was at least a section of the hull extending from the main gundeck down to the floor of the hold (Cotswold Archaeology 2016, Pascoe 2017b, p. 33). Whether it is the port or starboard side is not yet known. Trenches 1 and 4 confirmed the location of the floor, Trench 3 confirmed the location of the main gundeck, and Trench 2 identified the potential location of a platform deck between the bottom of the gundeck floor and the bottom of the hold (Figure 5.1). At this time there was no complete orlop deck, instead large ships like the *London* had a partial deck or platform located at the forward and aft ends of the ship. These areas were not connected by a continuous deck and were only planked along the sides to accommodate the stowage of cables and ropes. It wasn't until *c.*1670 that a continuous deck, known as the orlop, was laid down (Fox 2011, p. 17). Trenches 2 and 3 are most relevant to understanding the *London's* naval gunnery system and will be discussed below.

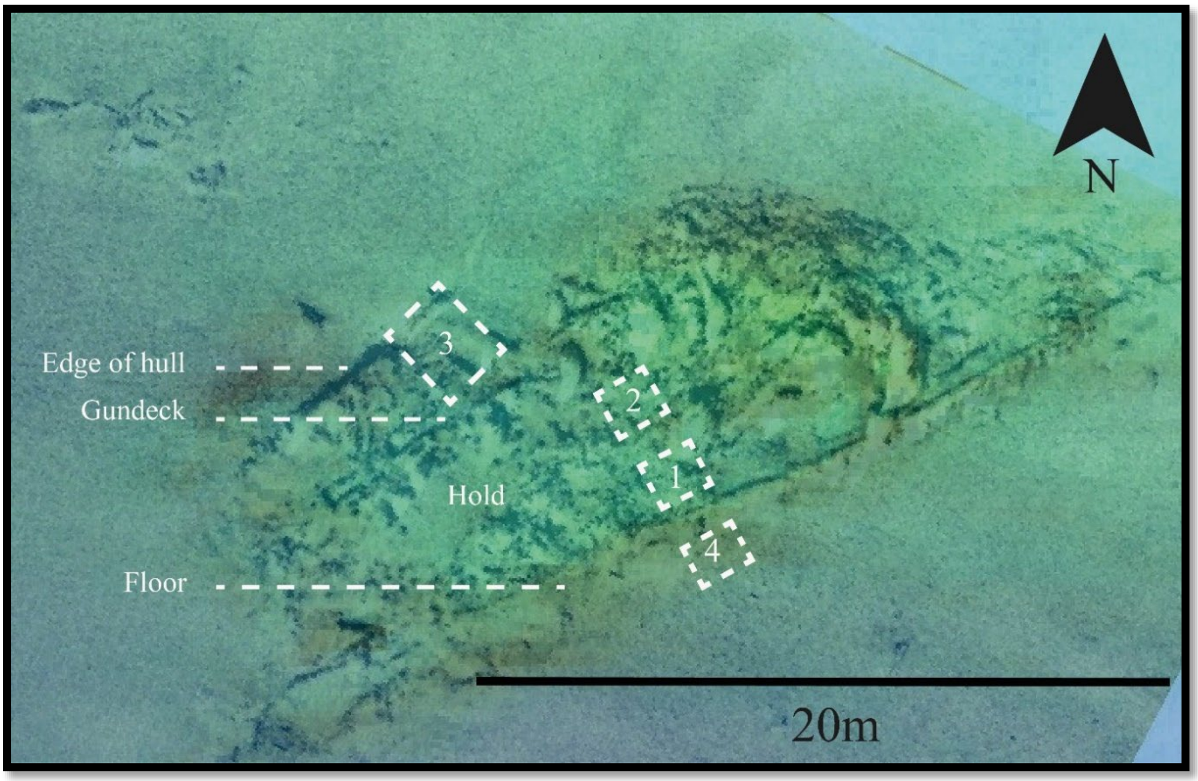

Figure 5.1: Multi-beam bathymetry image and sidescan sonar image combined of Site 2 with positions of Trenches 1-4 and annotations of known structural features (Geophysical image Wessex Archaeology (Wessex Archaeology 2010)).

The following sections, 5.2.1 – 5.2.2, will introduce the parts of the ship revealed by the excavation of Trenches 2 and 3 and how they relate to the *London's* gunnery system. Sections 5.3 – 5.5 will then discuss the evidence found on the wreck for working the guns and for supply, organisation and maintenance of the gunnery system. Evidence from other archaeological sites of the time will be incorporated, including contemporary historical sources and iconographic data. Finally, section 5.6 will be a summary of key points.

5.2.1 *Trench 2 – Platform deck*

The excavation of Trench 2 was conducted during the 2014 season. Trench 2 was located roughly in the centre of the site, to the south was the floor of the hold and to the north were the remains of the main gundeck (Figure 5.1). A shallow 2m by 2m by up to 0.5m deep trench was excavated using hand tools. The full depth of the trench was not excavated due partly to the density of collapsed structures, and priority given to the excavation of Trench 3 and subsequent recovery of a complete gun carriage. The excavation of Trench 2 revealed a section of partition planking relating to internal structures of a compartment or cabin. Within this internal section of structure were large quantities of musket and pistol shot (Cotswold Archaeology 2014).

Musket shot was generally stored within the gunner's storeroom, so alongside the evidence of the internal partition planking, Trench 2 was potentially the location of the gunner's store. On large warships like the *London* at this time, the gunner's store was found on a platform deck between the floor of the main gundeck and the floor of the ship. This was a partial deck located at the forward end of the hold (Fox 2011, p. 17).

5.2.2 *Trench 3 – The main gundeck*

Trench 3 was located on the northwest edge of the site between the side of the hull and the deck of the main gundeck (Figure 5.1). This trench was excavated throughout the entire period of the excavation project as it is an incredibly well preserved and artefact rich area of the wreck in just a 2m long by 1.5m wide and 1.3m deep trench. The remains of the deck lie at an angle of 45 degrees, showing that the remains of the hull were lying healed-over to one side, as opposed to upright (Figure 5.2) (Cotswold Archaeology 2014, 2015, 2016, Pascoe 2017a). The excavation located a complete gun carriage, with associated gun tackle and many other gun related equipment, lying adjacent to its gunport.

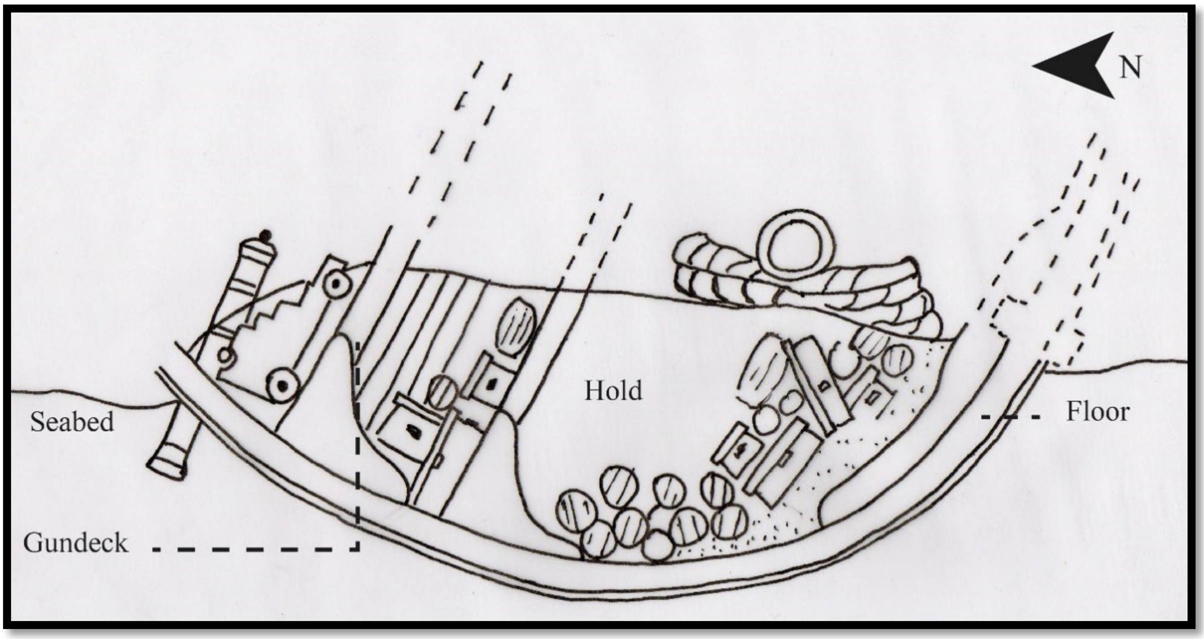

Figure 5.2:A cross-sectional sketch to illustrate the orientation of surviving hull structure from Site 2 (Sketch by author).

Despite this wealth of evidence, however, the gun was missing, having been one of five guns illegally salvaged from the site in 2007. Subsequent research by the author has identified the likely candidate as a Dutch 24-pounder cast in 1600 by Conraet Antonis, one of eight issued to the *London* in 1664 (Pascoe 2017a, p. 44). The other guns included a Commonwealth demi-cannon, cast by George Brown in 1656, a Tudor culverin cast by Peter Gill in 1595 and re-bored as a 24-pounder; and two other Dutch 24-pounder cast in 1616 and 1617 respectively by Gerard Koster (Fox 2011, Pascoe 2017a, pp. 43–45). These were all guns from the *London's* main gundeck demonstrating that there was no strict issue of a homogeneous battery on each deck (Figure 5.3 and 5.4).

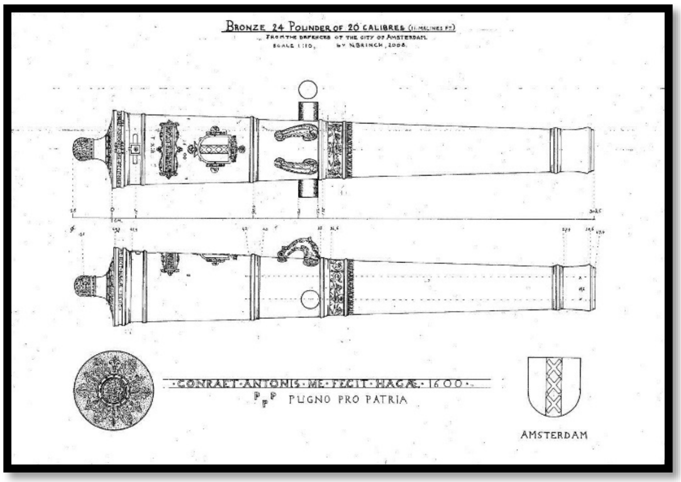

Figure 5.3: Illustration of one of the three Dutch 24-pounders. This is the Conraet Antonis cast in 1600 that fits the gun carriage recovered from Trench 3 (Drawings © Nico Brink).

Figure 5.4: On the left the Cromwellian Demi-cannon and on the right the Tudor Culverin bored out to become a 24-pounder.

5.2.2.1 Main gundeck survival

The main gundeck of the *London* accommodated 16 demi-cannon, eight 24-pounders and two culverin chase guns (Fox 2011, p. 27, Pascoe 2017a, p. 31). The area excavated found the location of a single gun station for one of the *London's* 24-pounder guns (Pascoe 2017a). The forward part of the carriage was found butting up against the sill of the gunport. When the carriage and many other artefacts were removed, the deck was found to be in excellent condition. Approximately a 2m by 1.3m section of the deck was uncovered consisting of at least five rows of planks. The size of the planking was irregular, and caulking was present between the seams. The density and complexity of artefacts and collapsed structure meant the bottom of the trench was not reached, this included the area between the sill of the gunport and the deck (Cotswold Archaeology 2016, p. 23).

The excavation uncovered the extent of the gunport and approximately 0.5m of the inside of the hull to the right of the port and 0.3m to the left of the port. The internal size of the port was 900mm (35.4 in) wide and the height of the port survived 800mm (31.5 in) above the sill. Looking from the inside towards the gunport there was a single concreted ring bolt fastened to the side of the hull to the right and just below the level of the port sill (Figures 5.7 and 5.23). There was no evidence of a second immediately next to it or above it. The ring bolts were used to secure the end of the guns breeching rope. The remains of a wooden hanging knee were situated 0.5m from the right side of the port (Figure 5.23). There were two concretions on its upper surface. It is possible that one of these concretions could be the remains of an eye bolt used for attaching one end of the gun tackle. The left side of the port was not excavated to the extent where ring or eye bolts could be identified. A loose ring-like concretion was recovered from the trench, but this may have originated from the gun carriage (Cotswold Archaeology 2016, pp. 23–24).

As well as the carriage with its associated gun tackle, many different types of gun accessories and equipment were recovered, too many in fact for the use of one gun. There was also a broken chest containing leather bandoliers with powder boxes, containing single charges of powder and priming flasks, with a spout instead of a lid. A total of approximately 90 powder boxes were recovered with many more left within the chest and reburied (Cotswold Archaeology 2016, p. 31).The bandoliers would have been worn across the chest of the ship's musketeers and powder boxes used to load their muskets or pistols with powder (Figures 5.5 and 5.6). The location of all this equipment and munitions at a single gun station was not the normal arrangement on board a warship and an explanation for their presence here will be discussed in section 5.5.

Figure 5.5: A selection of the powder boxes (Photo by author).

Figure 5.6: Leather bandolier with two powder boxes and one priming flask. The bandolier did have the fixing holes for up to 12 powder boxes (Photo by author).

5.3 EVIDENCE FOR WORKING THE GUNS

The evidence for working the guns on board the *London* comes predominantly from the material recovered and structures recorded in Trench 3. Additional information has come from in-situ observations and recovery of exposed surface artefacts from other nearby areas of the site after the excavation. Considering Trench 3 was only 2m long by 1.5m wide and 1.3m deep, a wealth of material relating to working the guns was recovered from this location. This information will provide all the evidence for understanding how a main gundeck gun was secured, mounted, manoeuvred and fired on board the *London*. Despite much of the equipment found in Trench 3 not being associated to this gun station, as mentioned above, it will provide both information relating to the other guns on board as well as critical evidence for reconstructing the final acts of the crew before the ship blew up.

Sections 5.3.1-4 will describe the function and form of the objects and mention briefly where they were recovered from. The significance of their location will be discussed in the following sections 5.4 and 5.5, 'supply, organisation and operation'.

5.3.1 *Mounting the guns*

The carriage

The carriage was found in-situ, facing the gunport with the front of the carriage cheeks butting against the sill. Two double blocks with the remains of the tackle were located at the front of the carriage on the outside of the cheeks. Two single blocks were located between the centre and rear of the carriage on the outside of the cheeks. Sections of breeching rope were found by the sides of the carriage (Figure 5.7). These were removed before the carriage was lifted and will be discussed in section 5.3.2.

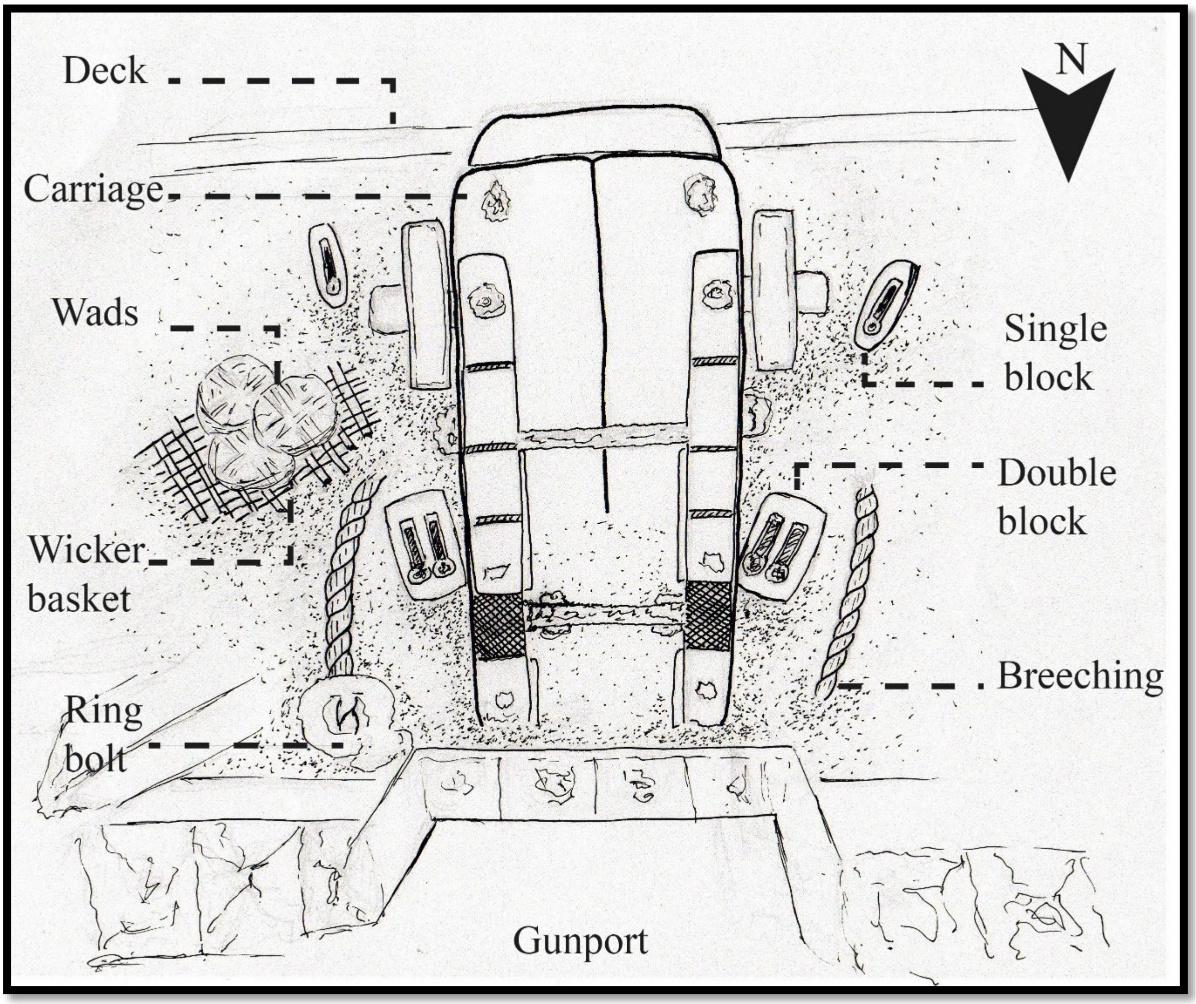

Figure 5.7: Sketch showing location of carriage and other equipment adjacent to gunport (Author's sketch).

The carriage is commonly known as a truck carriage (Smith 2001, p. 27, McElvogue 2008). It consists of two stepped trunnion support cheeks, each constructed from a single piece of timber with chamfered edges (Figure 5.8). The depth of the chamfers are greater on the horizontal edges along the top of the steps than the vertical edges. They are secured at the rear by means of iron bolts that secure the rear axle to the carriage and at the centre by a single tenon set into mortises cut into the lower edge of the cheek and upper face of the bed and secured in place by two wooden dowels. The cheeks are also secured to each other transversely by two iron through-bolts (Figure 5.10). The cheeks have four steps, used as leverage points for hand crow leavers and crow bars, to elevate or depress the breech of the gun (Figure 5.8). At the front end of the cheeks are deep trunnion recesses and either side of the recess are rectangular bolt holes, which identify where the iron cap squares were attached (Figures 5.8, 5.12 and 5.14). The cap squares were missing, lost when the gun was salvaged, but they would have been hinged at the rear and folded over to secure the trunnions to the carriage. The partial remains of the iron pins survive in the front holes. They would have protruded above the top of the cheek and had a hole for locating a linchpin that would have secured the cap square in place (Smith 2001, p. 28).

Figure 5.8: Photo of the carriage pre-conservation (Photo by author).

The bed of the carriage consisted of two planks secured together down their length by two tenon and mortise joins, similar to the cheek arrangement (Figure 5.9). The bed has shallow chamfered edges and is wider at the rear, the cheeks follow the taper of the bed. The rear corners of the bed are rounded, whereas the front are square cut.

Figure 5.9: Photo showing the bed made of two planks, taken post-conservation (Photo by author).

The front axle is secured to the bed of the carriage by two iron bolts. These bolts can be seen protruding out of the top of the bed and inside the cheeks (Figure 5.10). Evidence from a similar type of carriage displayed at Windsor Castle shows that the bolts were inserted upwards from the bottom of the axle and secured at the upper surface of the bed by a thin iron wedge, hammered through slots at the top of the bolts. A washer separated the wedge from the bed for protection (Figure 5.11) (Smith 2001, p. 28). The height of the concreted bolts on the inside of the cheeks of the *London* carriage suggest a similar fastening method to that of the Windsor Castle carriage.

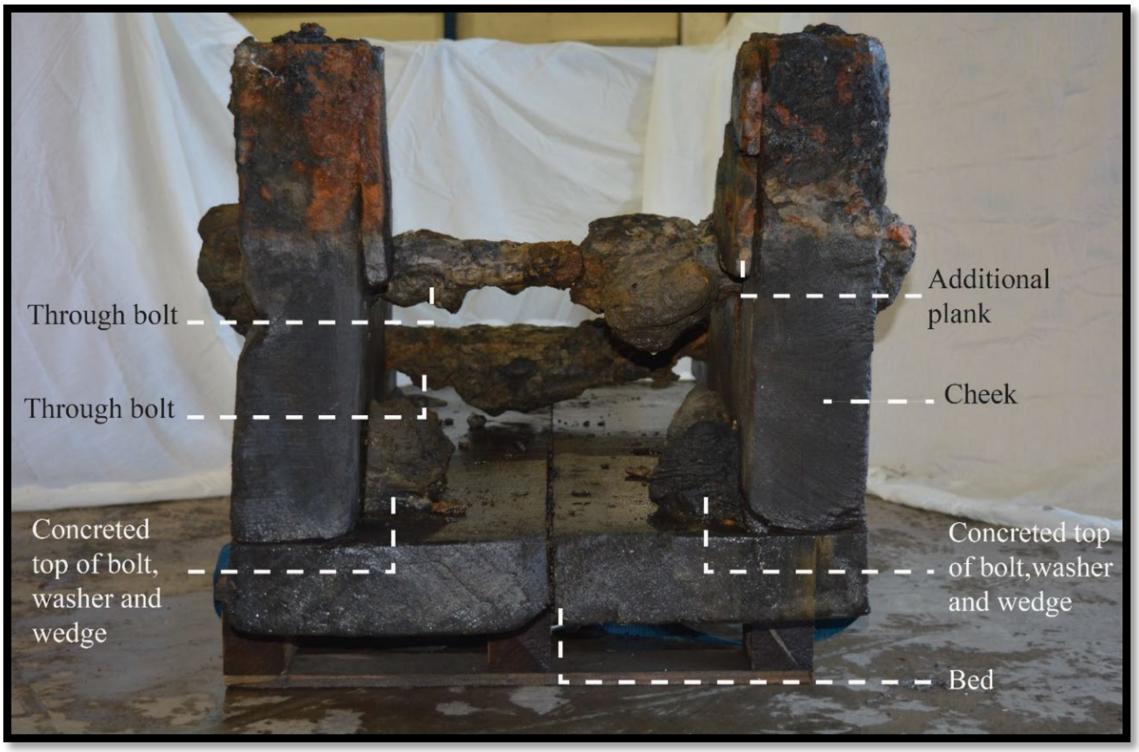

Figure 5.10: Photo showing tops of concreted iron fastening on the inside of the cheeks coming through the bed of the carriage from the location of the front axle (Photo by author).

Figure 5.11: The top of the iron bolt, including washer and forelock, which secures the front axle to the bed of the carriage (Photo courtesy of Kay Smith and Ruth Brown).

The ends of the front and rear axles are rounded to accommodate the trucks. The trucks were secured in place by iron pegs that passed through holes drilled into the protruding ends of the axles (Figure 5.12). The front trucks are significantly larger than the rear trucks.

Figure 5.12: The rear axle at the centre of the photo showing the concreted remains of an iron pin to secure the truck (Photo by author).

These features are common with other carriages found in terrestrial collections, such as the Windsor Castle carriage and shipwrecks, such as the *Stirling Castle* and Duart Point wreck examples (Smith 2001, McElvogue 2008, Martin 2017). Indeed the fragments of a cheek attached to a gun from the Elizabethan wreck off Alderney is almost identical in form to that of the *London*, demonstrating that this design of carriage was introduced at least as early as the 1590s (Monaghan and Bound 2001, p. 50). However, there are features present on the *London* carriage that indicate modification, making it unique and customised to support a specific gun – not that which it was made for. These alterations include a timber extension piece fastened to the rear of the bed (Figure 5.13), two thin planks of wood attached to the inside of the cheeks and around the trunnion recesses (Figure 5.14), and a timber plank added to the top surface of the front axle (Figure 5.15).

Figure 5.13: Photo showing timber extension at rear of the carriage.

Figure 5.14: Photo showing planks on inside of the cheeks.

Figure 5.15: Photo showing timber plank above the remains of the front axle.

This would not have been the only customised carriage on board. The recovered main gundeck guns have demonstrated that the guns from the main gundeck were not just a mix of calibres but also varied in length and girth. With the exception of the two Koster 24-pounders the other guns would have required carriages of different lengths and widths between the cheeks. Due to the lack of standardisation with the arming of the ships, customising carriages would not have been unique to the *London*. Alterations to carriages are even described by contemporary specialists, for example the ex-Officer, Surveyor and Controller of the Ordnance in Ireland, Captain Francis Povey, was very specific about the alterations made to carriages to make them suit the gun:

''He (the gunner) must be very circumspect in fitting his guns to the carriages, for it cannot be supposed that such carriages will truly fit; being not designed for the guns; if too large in the body you must line it with cleats of plank, if too small you must takeaway wood from the bracket'' (Povey 1702, p. 13).

This description exactly matches the thin planks of wood found on the inside of the cheeks. Povey also goes on to state that:

''Be sure your carriage be full long enough, otherwise you cannot place your beds and coyness to advantage, and if the carriage be short, and checked by the reverse, it may overset your gun.''

''You must take care your trunnions have no play under the capsquares, for the firing, your guns will dance and spue her coyness, which will cause the muzzle to strike against the edge of the port, and perhaps break the gun'' (Povey 1702, p. 12).

In the case of the *London's* carriage the extension piece was added to increase its length, which would have enabled better security of the stool bed and coins. A thin residue of an unknown material was also found in the trunnion recesses (Figure 5.16). Similar residue was found on carriages from the *Mary Rose* and was termed as a 'pillow' (Hildred 2011, p. 43). These 'pillows' were made of iron and they were used because the trunnions of the gun were too small for the recesses.

Figure 5.16: Photo showing possible residue on the inside of the trunnion recess.

They were therefore used as a packing device to stop the trunnions from jumping around when the gun was fired. The alterations recorded on the *London* carriage identify that it was adapted to support a longer and narrower gun. Of the five main gundeck guns recovered from the site the most likely candidate for the gun was the Dutch 24-pounder cast by Coentraet Antonis in 1600, due to its length and girth (Pascoe 2017a, p. 47) (Figures 5.3 and 5.17). The addition of the plank of wood between the front axle and the bottom of the bed was to raise the position of the gun so it was positioned in relation to the centre of the gunport. There was no evidence of the stool bed or coin, but these could have easily become dislodged during the wrecking event and floated away.

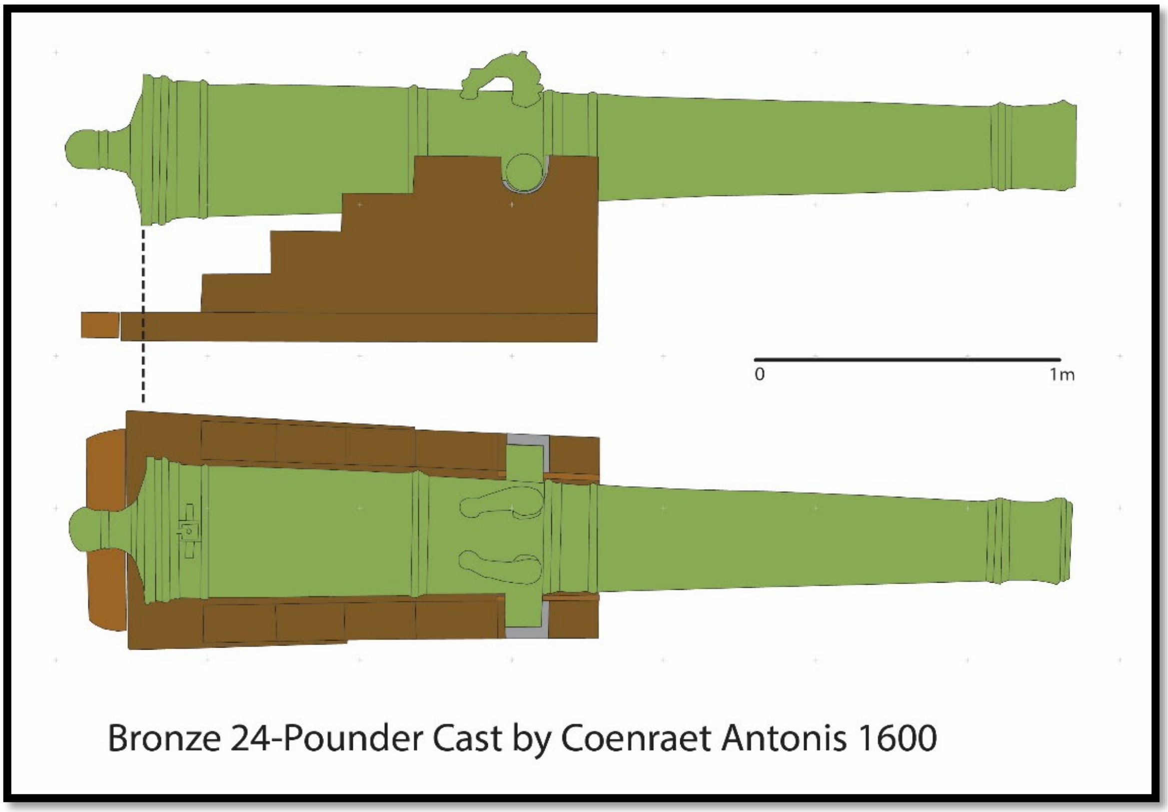

Figure 5.17: Illustration by author to show how the Dutch 24-pounder cast by Coenraet Antonis in 1600 fitted the carriage ((Pascoe 2017b, p. 46).

During this period there was another variation of the truck carriage known as the rear chock carriage due to the rear trucks being replaced by static chocks or skids (Martin 2017, p. 154). This alteration was introduced with a type of gun, known as the drake. The English version of the drake was developed by the gun founder John Browne in 1627 and they became widely used under the navies of Charles I and the Protectorate (Towes and McCree 1994, pp. 39–43). They were initially designed to make a cheap, lightweight gun without reducing the weight or range of the projectile (Martin 2017, p. 145). One of the main characteristics of the drake was a tapered breech, which is evident from recovered examples, such as the minion drake from the Cromwellian Shipwreck at Duart Point (Martin 2004, 2017) and a culverin drake recovered of the coast of Holland (Wilson 1988). The combination of a lightweight gun, heavily shotted and with a tapered bore, led to the drakes having a lively recoil. This led to the trucks at the rear of the carriage being replaced by fixed chocks. The static chocks would increase friction with the deck and therefore check the recoil of the gun (Martin 2017, p. 154).

The carriage found at Windsor Castle is a perfect example of a rear chock carriage (Figure 5.18) (Smith 2001). There is no rear axle, instead a block of wood is fastened directly to each side of the bed, with two iron bolts. The blocks are shouldered and taper from the top to the bottom, and the lower face, which is in contact with the deck, is flat. This flat surface would increase the friction with the deck. The height of the carriage also slopes down from the front to the rear (Smith 2001, p. 28). This would help transfer the force created by the recoil to transfer down onto the rear chocks. The latter combined with the static chocks would reduce the recoil of the gun. Authors such as Martin (Martin 2017, p. 153) and Caruana (Caruana 1994, pp. 181–2) have demonstrated the popularity of the adoption of the rear chock carriage alongside the drake with a citation dated 1 May 1639, which refers to the *Sovereign of the Seas* having carriages all of whole trucks and half trucks.

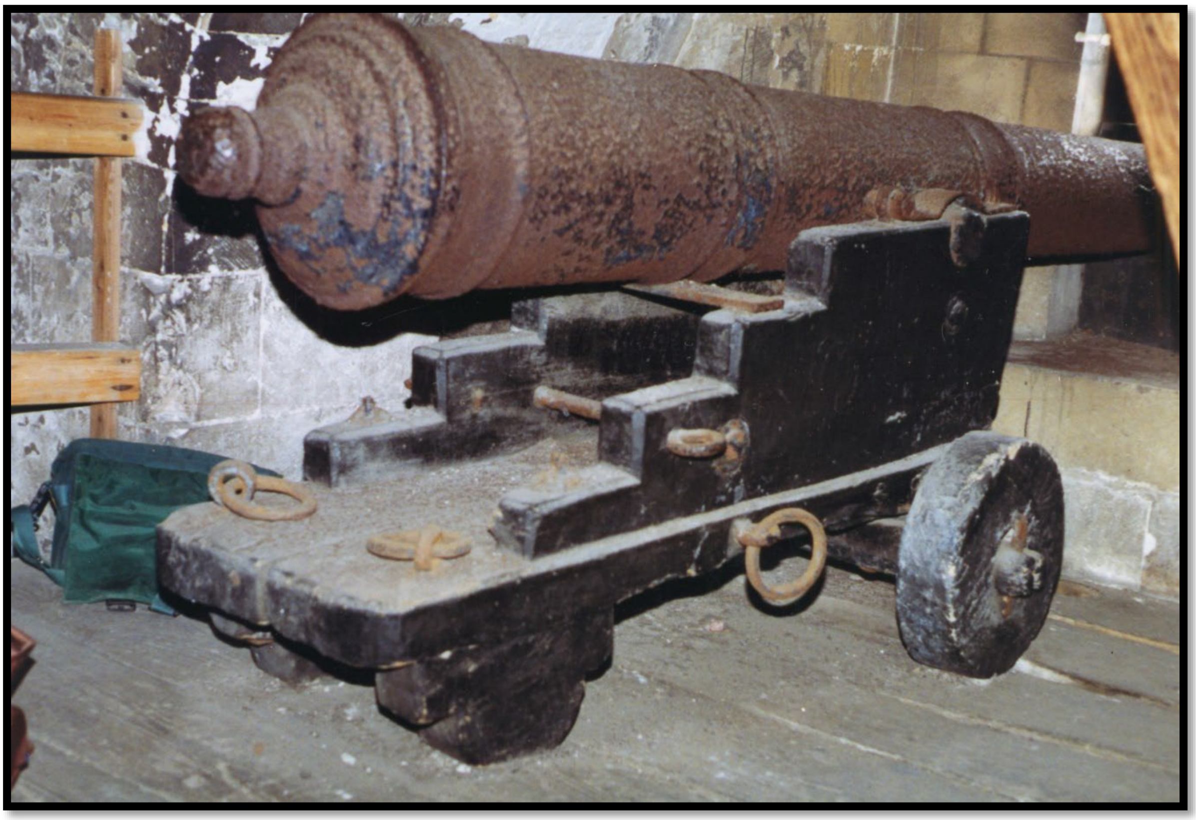

Figure 5.18: The chock carriage at Windsor Castle (Photo courtesy of Kay Smith and Ruth Brown).

Iconographic evidence directly relating to the *London* shows that the use of chock carriages was still common into the second half of the 17th century. A plan of the *London* including a midships section shows the lower and second tiers with guns mounted on rear chock carriages (Figure 5.19). Accompanying the plans was also a list of guns supposedly for the ship's first voyage out of Chatham on the 13th October 1657, it includes six culverin drakes on the second tier. However, neither the plan or accompanying ordnance list match the actual guns issued to the *London* for her first voyage which included nine specially cast iron cannon of seven (Fox 2011, p. 21). These were short and lightweight and, like the drake, would have also had a lively recoil (Fox 2011, p. 25). As such, it is possible that these guns were also fitted with the rear chock carriage.

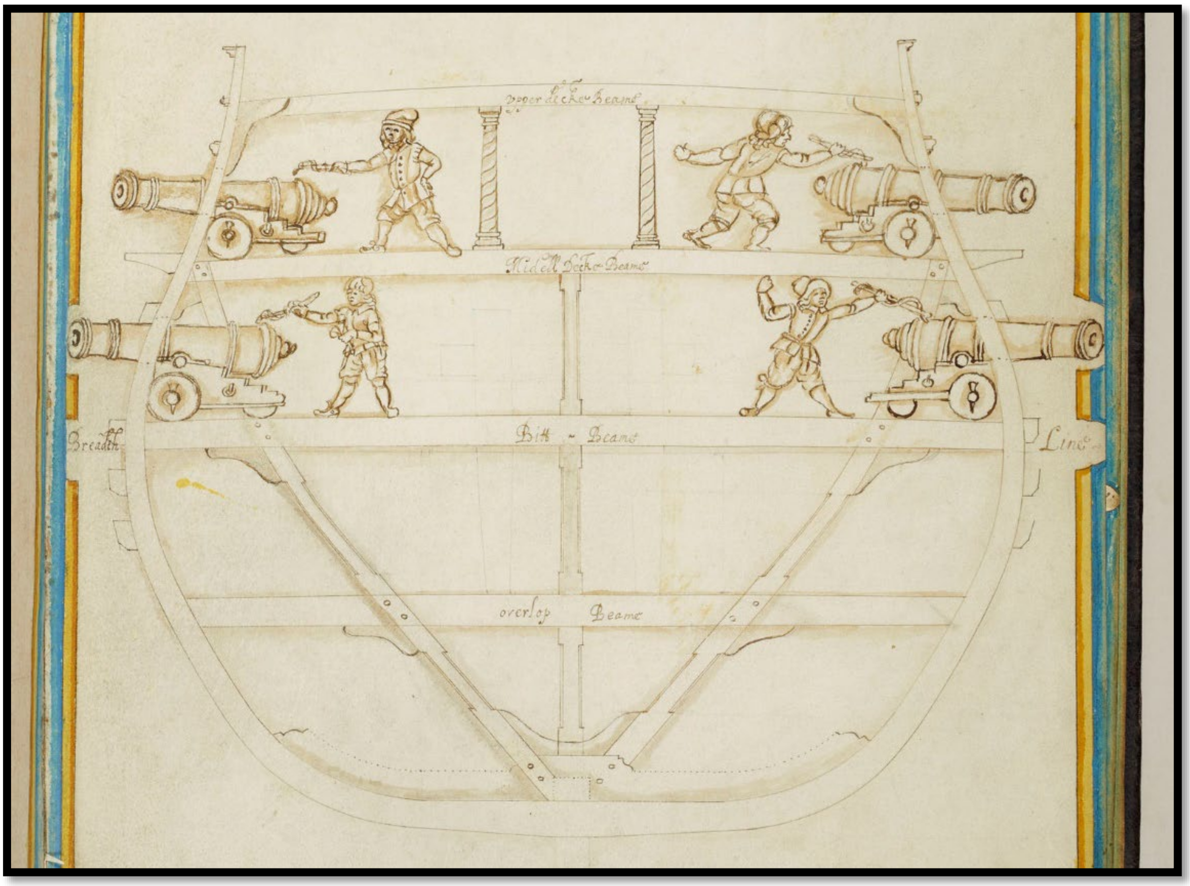

Figure 5.19: Amidships section of the *London* showing guns on the lower and second tier with rear chock carriages, which were generally associated with drakes (Image RCIN 1047387 Courtesy of Royal Collections Trust © Her Majesty Queen Elizabeth II 2021).

5.3.2 *Securing and manoeuvring the guns*

Breeching

The evidence for securing and manoeuvring the guns on board the *London* comes entirely from Trench 3. When excavating around the carriage, remains of the breeching rope for the gun were found between the inside of the hull and outside the carriage cheeks, additional broken pieces were also found near the rear of the carriage. On the right side of the cheek (facing the inside of the hull) the breeching rope passed round the outside of the double block located on the side of the cheek of the carriage, just behind the trunnion recess. The route of the breeching came from the side of the hull and headed towards the rear of the carriage (Figures 5.7 and 5.20). The breeching was extremely fragile and fragmented but several sections of it were recovered for analysis. All three pieces were three stranded hawser laid rope (in a Z-twist) with a circumference ranging from 184 – 203mm (7 ¼ - 8 inches) (Figure 5.21). The range in size is probably due to the rope losing its original tightness and form when fragmented.

Figure 5.20: A still image taken from GoPro footage showing breeching rope and double block outside the cheek of the carriage.

Figure 5.21: Photo of a section of breeching rope recovered from Trench 3.

Following the recovery of the carriage further excavation revealed a single concreted ring bolt on the right side of the gunport, just below the level of the sill (Figures 5.7 and 5.23). Although the left side of the gunport was not excavated to the same extent as the right, it is likely that at least one ring bolt would have been in a similar position. To secure the gun the breeching rope would have been tied onto the ring bolts on the side of the hull, passed through ringbolts on the sides of the carriage and then extended around the breech end of the gun. The ring bolts did not survive attached to the carriage, but the fastening holes for the ring bolts are visible on the side of the bed between the axles (Figure 5.22) and is present on the Windsor Castle carriage (Figure 5.18).

Figure 5.22: Photo showing fixing holes for eye and ring bolts. The breeching rope went through the ring bolt and the gun tackle hooked into the eye bolt (Photo by author).

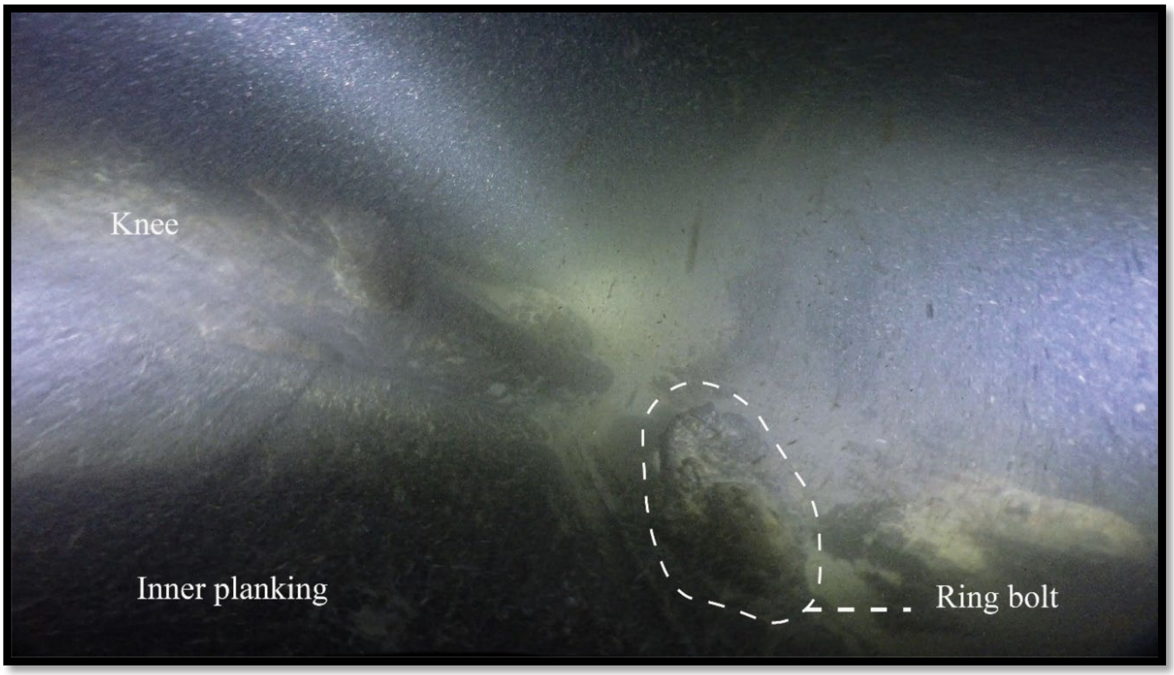

Figure 5.23: Photo showing the location of the ring bolt on the inside of the hull to the right of the gunport.

Gun tackle

The excavation revealed that the gun was manoeuvred into the firing position by the gun tackle, which consisted of a double and a single block on each side of the carriage (Figures 5.7, 5.20 and 5.24). Mainwaring explicitly describes the use of double blocks for manoeuvring the guns in his seaman's dictionary of the early 1620s (Mainwaring and Perrin 1921, p. 100). To secure these blocks to the side of the hull and the carriage each would have had an iron hook, attached via a strop around the cheeks of the blocks. These hooks would have hooked onto eye bolts located on the side of the carriage and the side of the hull, but none of these fittings were found. Although the rectangular holes for the eye bolts do survive on the side of the cheeks, just below the level of the third step (5.22). The double block ends were attached to ring bolts on the side of the hull and the single block ends were attached to eye bolts on the side of the carriage (Figures 5.18 and 5.22). According to a contemporary writer, John Seller writing in 1690, the rule for the length of the gun tackle was:

''*that as many feet as your piece is in length, so many fathom must your rope be''* (Seller 1691, p. 186).

The sizes of the respective blocks were similar but not completely uniform. There were differences in the materials used for their construction (Table 5.1). The cheeks of the blocks were all made of elm but for moveable components, such as the sheaves and pins, four types of wood were used. When the *London* came into Portsmouth in November 1664 the ship was supplied with various gunner's stores that had been requested by Master Gunner Gabriell Walters (TNA WO55/331). These included six, eight and nine inch blocks for tackle. The *London's,* although all slightly different, fit within the range of eight to nine inches, with the exception of single block **3052**, which is just under eight inches but too small to be counted as a six inch block (Table 5.1). This range in size is an indicator that they were all made individually by hand. The main body of the blocks were made from a single piece of timber, so the overall size would be dependent on the piece of timber chosen. When making by hand from natural materials, no two pieces will be identical; a difference of a few centimetres would not affect the performance of the blocks.

Artefact number	Type of block	Length of cheek (mm)	Width of cheek (mm)	Diameter of sheave (mm)	Wood species		
					Cheek	Sheave	Pin
3052	Single	200	140	132	elm	elm	holly
3120	Single	222	156	133	elm	elm	beech
3127	Double	210	165	105	elm	elm	holly
3358	Double	225	160	140	elm	ash	pomaceous fruits

Table 5.1: Showing sizes and wood species of blocks.

The Conraet Antonis gun length from muzzle to basering was 3.085m, which is a little over 10ft. From Seller's formula the length of the tackle would have been approximately 60 feet long (one fathom equals 6 feet. 6ft x 10ft = 60ft).

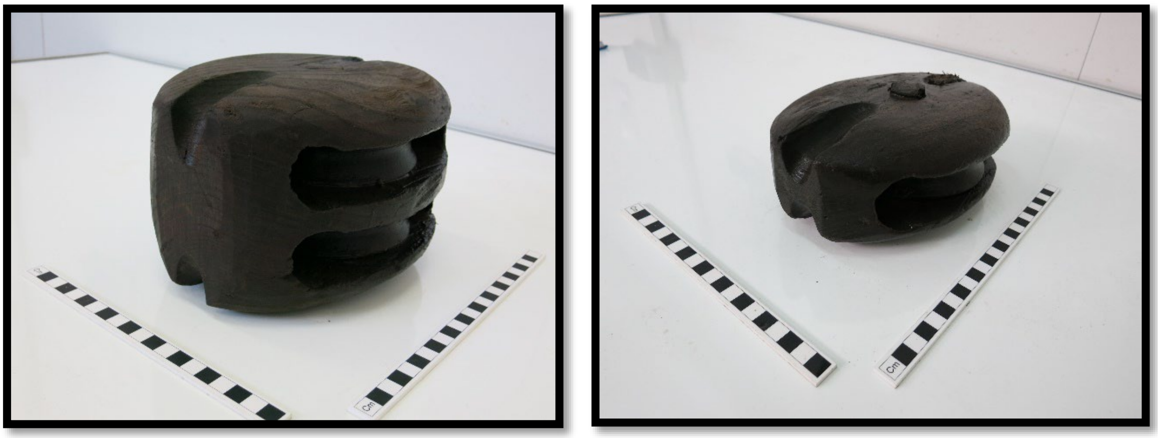

Figure 5.24: On the left double block **3127** and on the right single block **3120** (Photos by author).

Hand crow leavers

The Chatham Ledger states that the *London* was issued with 63 hand crow leavers (TNA WO55/1667) that were used for traversing the guns from side-to-side or elevating and depressing the breech (Padfield 1973, p. 58). The number of hand crow leavers were less than the number of guns on board, which means they were shared between guns and also that other implements, such as crows of iron, were used. This was not unusual at this time as according to the other ships listed in the Chatham ledger the number of hand crow leaver were also not equal to the number of guns (TNA WO55/1667). A possible explanation for this could be that the *London's* bow and stern chase guns shared equipment with the guns on the broadside, because it was unlikely that you would require all-round fire at the same time. The stern drawing of the *London* shows that the ship was armed with a total of eight stern chasers: four on the main gundeck and two each on the second and upper tiers. The bow drawing shows two guns each on the upper and second tiers (Figures 5.25 and 5.26). This meant there were potentially 12 guns that could share equipment, which would bring the number of necessary hand crow leavers down to 64. For the *London* to be issued with 63 does seem to be quite unusual. The number of hand crow leavers does appear to change by 1677 when an ordnance list for the rating of all ships identifies that hand crow leavers and crows of iron were equal to the number of guns on board (TNA WO55/1650).

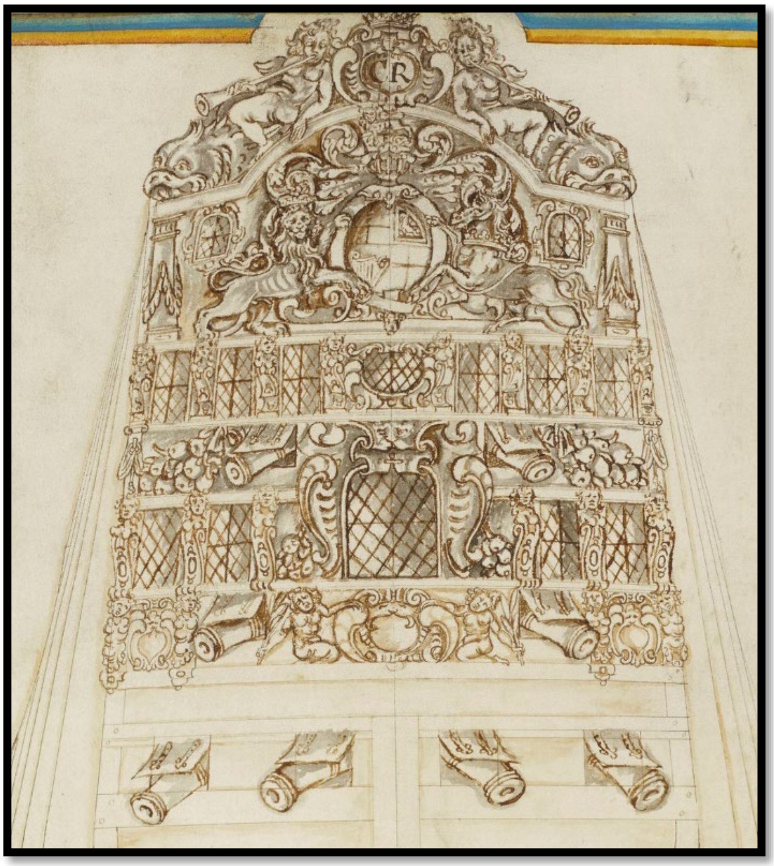

Figure 5.25: Contemporary illustration showing the stern view of the *London* showing stern chasers and decorations (Image RCIN 10447387 Courtesy of Royal Collections Trust/© Her Majesty Queen Elizabeth II 2021).

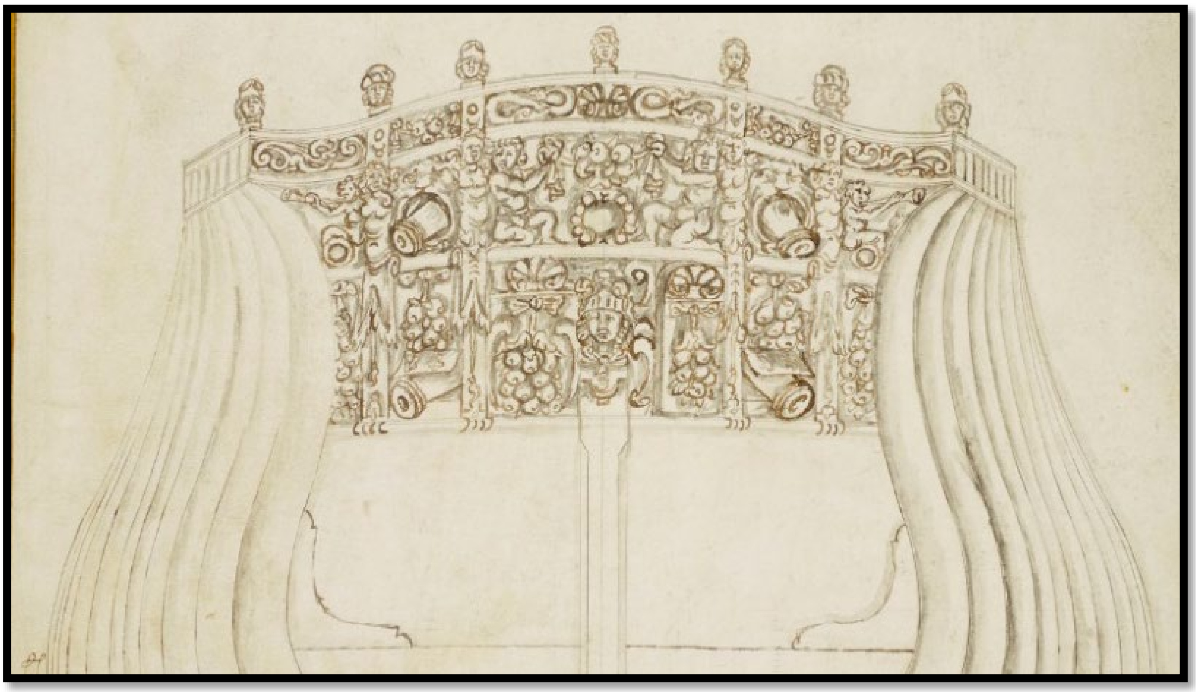

Figure 5.26: Contemporary illustration of the bow view of the *London* showing forward chase guns and decorations (Image RCIN 10447387 Courtesy of Royal Collections Trust/© Her Majesty Queen Elizabeth II 2021).

The excavation of Trench 3 recovered fragments relating to at least 20 individual hand crow leavers with four of those complete (Figure 5.27). Several others were left in-situ and re-buried (Figure 5.28). They were found grouped together on either side of the carriage, are all the same shape and design and also have the remains of an iron shoe at the head/lower end. The complete examples were roughly five feet in length and made of a single piece of ash (Hazell and Aitkin 2019, p. 6). Ash is a timber particularly resistant to stress (Gale and Cutler 2000, p. 120) and therefore ideal for dealing with the forces and stresses involved in manoeuvring heavy objects such as the guns.

Figure 5.27: Photo showing a group of hand crow leavers concreted together by their iron shoes (Photo by author).

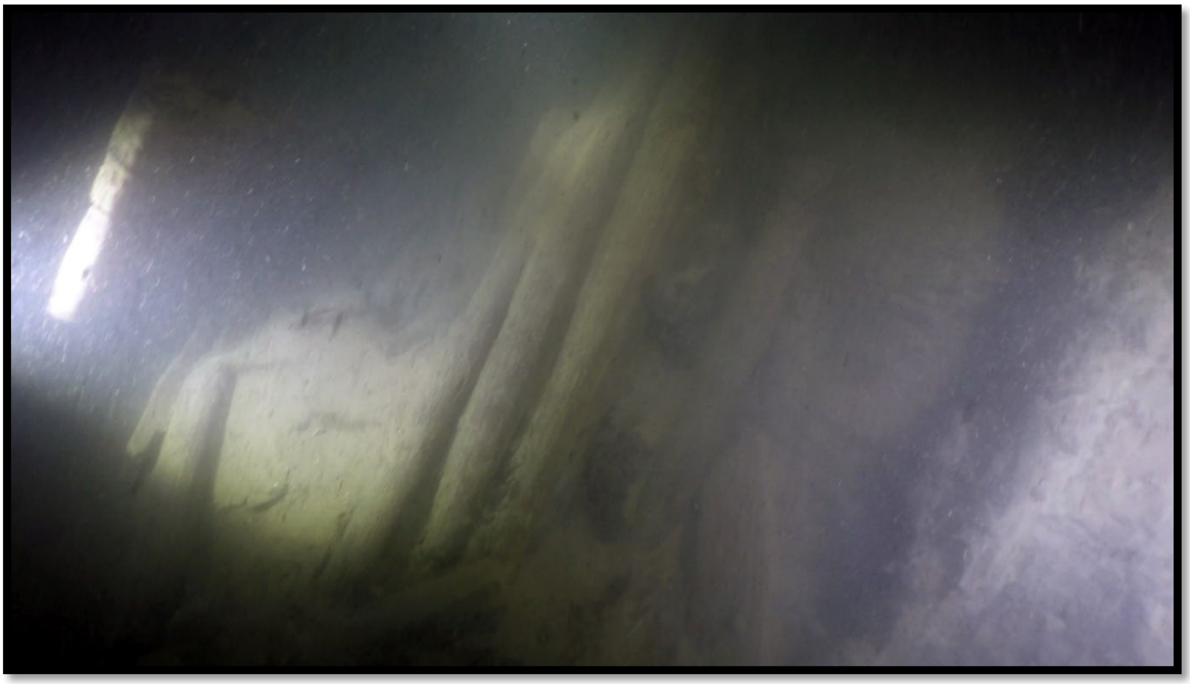

Figure 5.28: A group of hand crow leavers left in-situ (Photo by author).

Hand crow leaver **3358** will be described as an example. It is 1550mm (5ft 1in) long, ovoid in section at the handle end with a maximum diameter of 45mm. It is rectangular in section at the head end with a width of 70mm and breadth of 55mm. The head end is the end which would be placed under the carriage or breech. The remains of concretion around the head end shows it had an iron shoe. Radiography has identified that the iron shoe was fastened onto the head by a series of iron nails hammered into the flat face (Figure 5.29). The purpose of the iron shoe was to protect against wear and abrasion from heavy solid objects such as the carriages and guns.

Figure 5.29: Two radiographs showing the remnants of the iron shoe and iron fastenings (Radiograph courtesy of Angela Middleton, HE).

5.3.3 *Dressing the gun when not in use.*

Aprons of lead

An apron of lead is a square plate of lead that covers the vent hole of a gun, to keep the powder charge dry and vent clean and open (Blackmore 1976, p. 218). Within the Chatham ledger they are referred to as covers of lead and the *London* was issued with 76, one for each gun (TNA WO55/1667). Four have been recovered from different locations from Site 2 by the Licensee during routine site visits. The aprons are rectangular sheets of lead that have been fitted to the breech end of the gun and hammered to cover the base ring and the area containing the touch hole. The shape of the gun's mouldings and base rings are therefore present on the aprons. They either have a pair of holes or single holes on each side for securing a rope lanyard. The aprons range in size and this potentially corresponds with the size of the guns. Table 5.2 shows the dimensions of the recovered apron and the potential gun type they fitted. The author took the aprons to the Royal Armouries at Fort Nelson where three guns from Site 2 are being conserved and where the demi-culverin recovered in 1961 is on display. The shape and indentations of apron **3326** was a good match for the mouldings found on the Tudor Gun cast by Peter Gill in 1595, which was bored from a culverin to the size of a 24-pounder (Figure 5.30). This demonstrated that the apron was a size suitable for at least culverin and 24-pounders. None of the other aprons matched the mouldings of the other guns but apron **3323** was a good size match for the demi-culverin (5.31).

Apron Artefact Number	**Length (mm)**	**Width (mm)**	**Gun type**
3323	145	210	demi-culverin Or smaller
3326	235	260	24-pounder (mouldings match the Peter Gill 24-pounder, which was originally a culverin)
3341	254	237	culverin and above
3350	250	280	demi-cannon

Table 5.2: Dimensions of aprons recovered with possible gun type. Orientation: The length is the measurement of the apron when placed longitudinally along the length of gun, the width is the measurement of the apron across the gun.

Figure 5.30: Apron **3326** in position over the vent hole of the Tudor 24-pounder (Photo by author).

Figure 5.31: Apron **3323** with demi-culverin recovered from the *London* (Photo by author).

Tampions

By the period of the *London,* tampions were a turned wooden plug inserted into the muzzle of the gun to protect the bore and keep the powder charge dry when the gun was not in use.

They were sized to fit a specific gun type. This had changed from the period of the *Mary Rose* when they also had a second function of separating the powder from the shot (Hildred 2011, p. 463) and therefore they would be destroyed and replaced each time the gun was fired. This was why much greater numbers were listed in Tudor inventories (Henry VIII Tudor).

In the Chatham ledger they are referred to as tampeons and the *London* was issued with 100 (TNA WO55/1667). In the case of the *London* they have been found individually (Figure 5.32), either loose on the seabed, or in the case of at least one, lodged in the barrel of one of the guns recovered in 2007 (Fox 2011, p. 33), or in their spare form as a reel of six (Figure 5.33). The reel (**3832**) is turned from a single piece of timber and segmented into individual tampions by cutting grooves while on the lathe. The reel is shaped like an hourglass (Figure 5.33) and a core is left joining each segment (Figures 5.32 and 5.33). When needed the end tampion would either be broken or cut from the reel. Tampion **3803** shows evidence of torn fibres at its core suggesting it was snapped off (Figure 5.32). The tampions have a tapered profile with one face wider than the other. When placed into the muzzle of the gun the wider face was facing outwards. The diameter of the outer face of the tampion **3803** was 175mm (6.8 in) and the inner face was 170mm (6.7in). Although on the large size this tampion would be appropriate for the demi-cannon, but one that may have had a degree of wear at the entrance to the muzzle. This would not be surprising considering the age of several of the guns recovered from the site. The maximum diameter of the outer face of the tampions from the reel (**3832**) was 160mm (6.3 inches) and the inner face was 155mm (6.1in). This suggests these tampions were designed for the *London's* demi-cannon. Five of the tampions on reel **3832** are a similar thickness ranging from 32-28mm but the tampion at one end is considerably thicker at 52mm.

Figure 5.32: Tampion **3803**, note the centre core which joined it to the other tampions in the reel (Photo by author).

Figure 5.33: A reel of tampions (Photo by author).

5.3.4 *Loading and firing the guns*

Rope sponges

Rope sponges are sometimes referred to as a flexible rammer and sponge. It consists of the rammer head and sponge head situated at opposite ends of a stiffened rope. Within the Chatham ledger the rope sponges are listed on the same page as the powder horns with the return and issues columns side-by-side (TNA WO55/1667). There are dashed lines in the rope sponge columns, followed by 76 in the powder horn columns. The rope sponges were essential for loading the guns inboard. Inventories show that the sponge and rammer on the end of a solid stave or staff was shared between several guns and therefore not ideal for use in battle when each gun would have potentially needed to be capable of being reloaded simultaneously. This was suggested by Povey when describing the use of the rope sponge:

''*This sponge is used within board, because your staff spung cannot, unless your gun be along-ships, which will hinder the service of your guns on each side''* (Povey 1702, p. 29).

It is therefore likely that the dashed line indicates a ditto and therefore 76 rope sponges were issued to the *London* (TNA WO55/1667). The 1677 inventory for quantity of stores for each rate shows that the number of rope sponges were equal to the number of guns, demonstrating the importance of this piece of loading equipment (TNA WO55/1650).

From Trench 3 two rammer heads and one sponge head, along with partial remains of their rope, were recovered (Figures 5.34, 37 and 41). Two other rammer heads with rope were recovered by the site Licensee in 2018 from a location on the main gundeck within a few metres of Trench 3 (Figures 5.38-41). According to the Licensee there were other rammer heads with their ropes at the location where the later examples were recovered. The examples from the excavation will be described first followed by the later recoveries. Both rammer heads and the sponge head were recovered from the west side of the carriage along with pieces of rope still attached, other detached sections of served rope were also recovered. The analysis of the rope is critical in understanding the makeup of the rope rammers and sponges but first the heads will be described.

Figure 5.34: Photo of rammer heads **3206** (left of photo) and **3207** (right of photo) (Photo by author).

The heads of both rammers are turned from a single piece of timber into a conical cylinder, tapering from a maximum diameter at the face to form a neck into which the rope was threaded and secured by iron nails. Although they are similar in form, they do have several differences in their construction. Rammer head **3206** was made of poplar or willow (Hazell and Aitkin 2019, p. 33) and has an external diameter at the face of 127mm (5 inches). This size would be appropriate for an ordinary culverin and possible a great culverin (Table 5.3). It has a rope hole with a maximum diameter of 62mm (2.4in). It was fitted with three strand hawser laid rope. X-radiography identified that the hawser had a jaw angle of 52º and that it was secured in place by two iron nails driven horizontally through to counter sunk holes at the shoulder of the neck (Figure 5.35). The counter sunk holes ensured that the heads of the iron nails could not cause a spark if coming into contact with the barrel of the gun.

Gun type	**Bore size inches**	**Shot size inches**
cannon royal	8	7 ½
great demi-cannon	6 ¾	6 5/8
ordinary demi-cannon	6 ½	6 1/6
small demi-cannon	6 ¼	6
demi-cannon drake	6 ½	6 1/6
great culverin	5 ½	5 ¼
ordinary culverin	5 ¼	5
small culverin	5	4 ¾
culverin drake	5 ½	5 ¼
old demi-culverin	4 ¾	4 ½
ordinary demi-culverin	4 ½	4 ¼
small demi-culverin	4 ¼	4
demi- culverin drake	4 ½	4 ¼

Table 5.3: Bore and shot sizes of SBML guns taken from the author of The Complete Gunner, dated 1672.

Rammer head **3207** was made from a solid piece of alder (Hazell and Aitkin 2019, p. 33) and has an external diameter at the pushing face of 115mm (4 ½ inches). It shows subtle evidence of retouch along the outer face at the end nearest the face, suggesting it has been modified to fit a slightly smaller bore (Figure 5.36). This size would be appropriate for an old demi-culverin and possibly a small culverin (Table 5.3). It has a rope hole with a maximum diameter of 50mm (1.9in). X-radiography has identified that it was fitted with three hawser cable laid rope with a jaw angle of 46º (Figure 5.35). This was secured in place by three opposing diagonally penetrating iron nails into counter sunk holes.

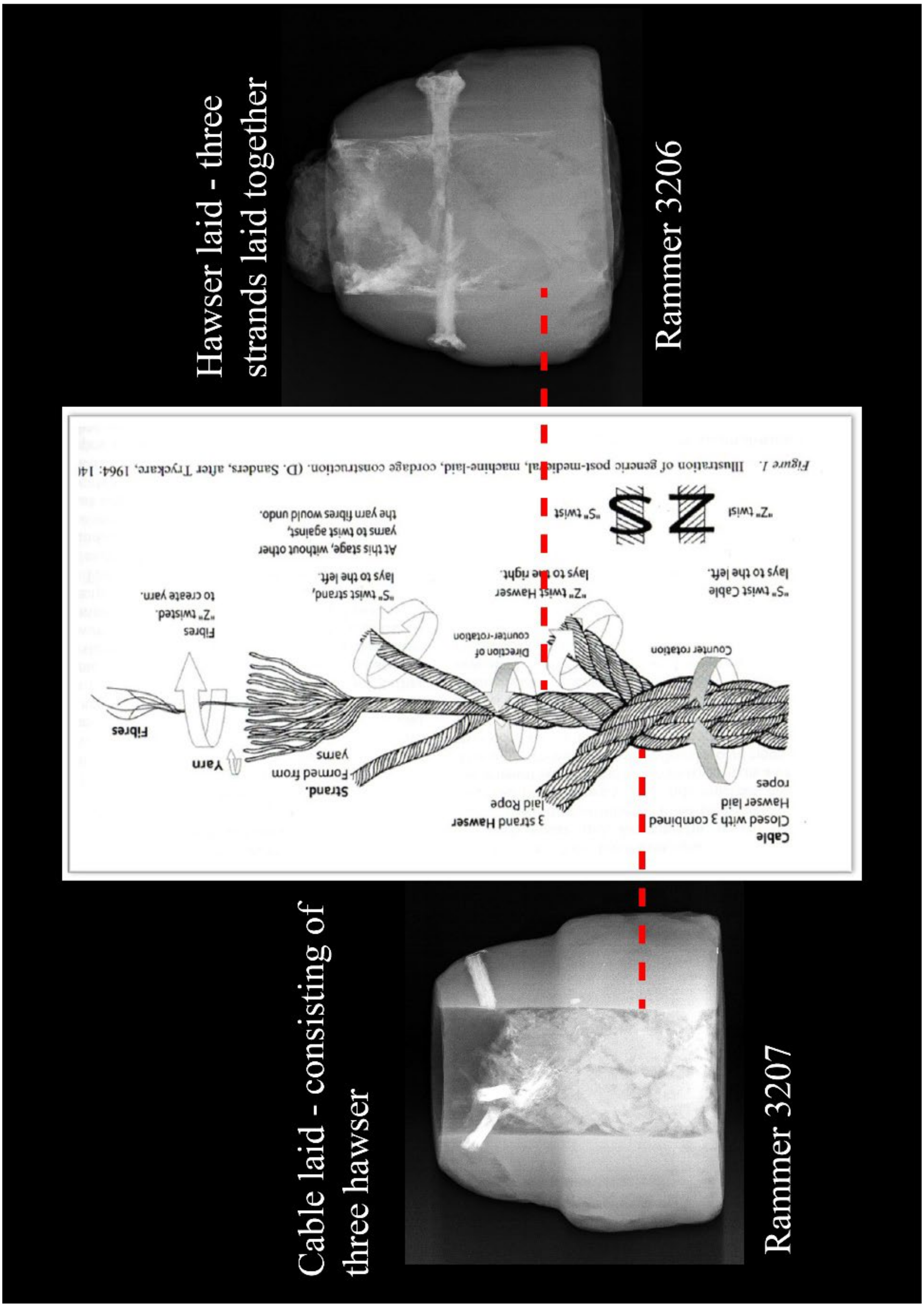

Figure 5.35: Radiographs of rammers **3206** (right of image) and **3207** (left of image) showing the form of the rope and position of iron fastenings (Radiograph courtesy of A. Middleton, HE, cordage illustration (Sanders 2010) and the combined illustration by author).

Figure 5.36:Photo showing tool marks around the outer of the rammer (Photo by author).

Two sections of wormed and served, three stranded hawser were recovered from the same location as the two rammers (Figure 5.37). However, as rammer **3207** was fitted with cable laid rope, this is likely to relate to rammer **3206**, although it is not possible to identify the serving in the radiographs. The served ropes **3173, 3208** and **3209** ranged slightly in size from 56-53mm diameters. They would have all fitted into the rope of hole of rammer **3206**.

Figure 5.37: A close-up photo of rope **3209** showing the serving and worming (Photo by author).

Two near contemporary descriptions of rope sponges mention in detail the importance of serving:

John Seller 1691:

‘‘*It is also approved by able gunners, that the rammers and sponges made with small hawser should be armed close and hard with strong and twisted yarn, from the rammers end quite to the sponge, which would much stiffen and make it more useful and lasting to ram both wad a bullet close to the powder’’* (Seller 1691, p. 186).

Francis Povey 1702:

‘‘When you cut your rope for this sponge, you must serve it well with spun yarn, or otherwise, which will stiffen it; or else you cannot ram your powder and shot. It also preserves your rope from perishing by the moist sulphurous matter which remains in the gun’’ (Povey 1702, p. 29).

As well as the serving the jaw angles recorded on the ropes of both rammers show the rope was twisted considerably tight. The twists that are put into the rope during manufacturer will effect properties such as strength, flexibility and handling (Sanders 2010, p. 15). The greater the angle, the stiffer the rope and this would have made it suitable for pushing a heavy object down the barrel of a gun. These ropes were also tarred which again would contribute to their stiffness.

The two rammer heads recovered since the excavation are extremely interesting in that they show considerable evidence of alterations indicating adaptations to fit a smaller calibre gun. Rammer **3801** has a maximum external diameter across the face of 135mm (5.3 inches). According to table 5.3, this would be too large for a culverin and too small for a demi-cannon and therefore it would be more appropriate size to fit the 24-pounder guns, which bores ranged from 151-152mm (5.9 inches). The 24-pounder was not a standard gun in the English Navy at this time (Fox 2011, p. 27) and so equipment would not have been made specifically for these types of guns and therefore would explain the retouch around the outer face of the rammer.

This particular rammer has been turned from a single piece of timber, not yet identified to species, and has been neatly shaved, probably with a draw knife, around the entire circumference of the head from 40mm (1.6in) below the shoulder down to the bottom edge. The rope hole has a maximum diameter of 57mm (2.2in), which was fitted with three strand hawser laid rope with a jaw angle of 50º. This has been fastened with a single iron nail at the shoulder. In addition, a wooden wedge has been inserted at the rope hole at the pushing face between the rope and the inside of the hole. There was also evidence of terrestrial insect infestation suggesting it was either not being used frequently when on board or it had been sitting around in stores for a prolonged period of time (Figures 5.38 and 39).

Figure 5.38: Rammer head **3801**, showing tool marks and wood worm damage (Photo by author).

Figure 5.39: Photo showing rammer **3801** with the wooden wedge that was inserted into the rope hole at the ramming face (Photo by author).

Rammer **3802** has a maximum external diameter across the face of 142mm (5.6 inches). It has been turned from a single piece of timber, not yet identified to species, and has been crudely reworked with a straight-edged tool from the top of the shoulder to the bottom edge to fit a smaller calibre of gun (Figure 5.40). This size would again be appropriate for a 24-pounder gun. The rope hole is tapered going from a diameter of 62mm (2.4in) at the top to 50mm (1.9in) at the bottom. It has been fitted with three stranded hawser laid rope, with a jaw angle of 50º. This was fastened with one iron nail below the shoulder. The tapering of the rope hole may be another method to help secure the rope inside the hole.

Figure 5.40: Photo of rammer head **380**2 showing tool marks (Photo by author).

The sponge head **3324** was located 0.5m to the west of rammer heads **3206** and **3207** at the top of the stratigraphy, which accounts for the biological damage. The sponge head would have originally fitted at the opposing end of the rammer head, but **3324** was found detached. The sponge head is made from alder (Hazell andAitkin 2019, p. 33) and is cone shaped expanding from a diameter of 80mm (3.1in) at the face to a maximum diameter of 116mm (4 ½ inches) at the shoulder (Figure 5.41), tapering again from the shoulder to the top of the neck. It has a rope hole with a 45mm (1.7in) diameter, fitted with three stranded hawser laid rope with a jaw angle of 40º and with a wooden plug inserted at the bottom. X-radiograhy identified at least one iron nail driven in diagonally from above the shoulder down into the core of the rope (Figure 5.42). Several shorter iron nails can be seen on the side of the head. These would have been used for fastening the sheepskin sponge (Figure 5.42).

Figure 5.41: Photo of sponge head **3324**, also showing wooden plug, which was inserted into the rope hole (Photo by author).

Without knowing the thickness of the sheep skin sponge that was fastened around the head it is difficult to definitively state the calibre of gun it was intended for. It is likely that the sheepskin could add a considerable thickness, increasing its overall diameter. It is probable that this sponge was intended for guns of culverins and above. The most diagnostic feature of this sponge head is its cone shape and, although it is difficult to determine the calibre of the gun, it is this shape that makes it possible to determine the type of gun it would have been designed for. The cone shape or tapered end makes it an ideal design to reach the end of the tapered breech of a drake, which was described above in section 5.3.4 A conventional sponge would not reach the narrower end of the breech and therefore potentially leave hot embers that could prematurely ignite the next powder charge placed into the gun. The drakes ranged in calibre from cannon drakes all the way down to minion drakes. It is thus possible, given the range of guns on board, that the *London* had a range of drakes on board from the quarter deck all the way down to the main gundeck, made more likely by the discovery of this tapered sponge head.

Figure 5.42: Radiograph of sponge head **3324** showing the iron fastenings at shoulder and across the sides of the head (Radiograph courtesy of A. Middleton, HE).

Wadding, gunwad or junk

Wadding were essential components of the loading process. They are balls of yarn picked from old rope known as 'junk'. Junk normally appears in the inventories of ordnance stores.

However, there is no mention of junk or wadding in the Chatham Ledger. Other contemporary inventories identify that second-rates would carry up to 40 cwt (2 ton) (TNA WO 47/3).

During the initial excavation of Trench 3, in the 2014 season, the edge of a wicker basket with wadding inside was observed near the top of the stratigraphy, on the east side of the carriage (Cotswold Archaeology 2014) (Figures 5.7, 5.43 and 48). This was likely to be the gun's immediate supply of wadding. Unfortunately, this was not seen again during the following seasons suggesting it had been lost due to natural seabed reductions in the intervening period. During the 2016 excavations of Trench 3 a partial gunwad was recovered. It was constructed from yarns of rope folded or wrapped into a tight ball (Figure 5.45).

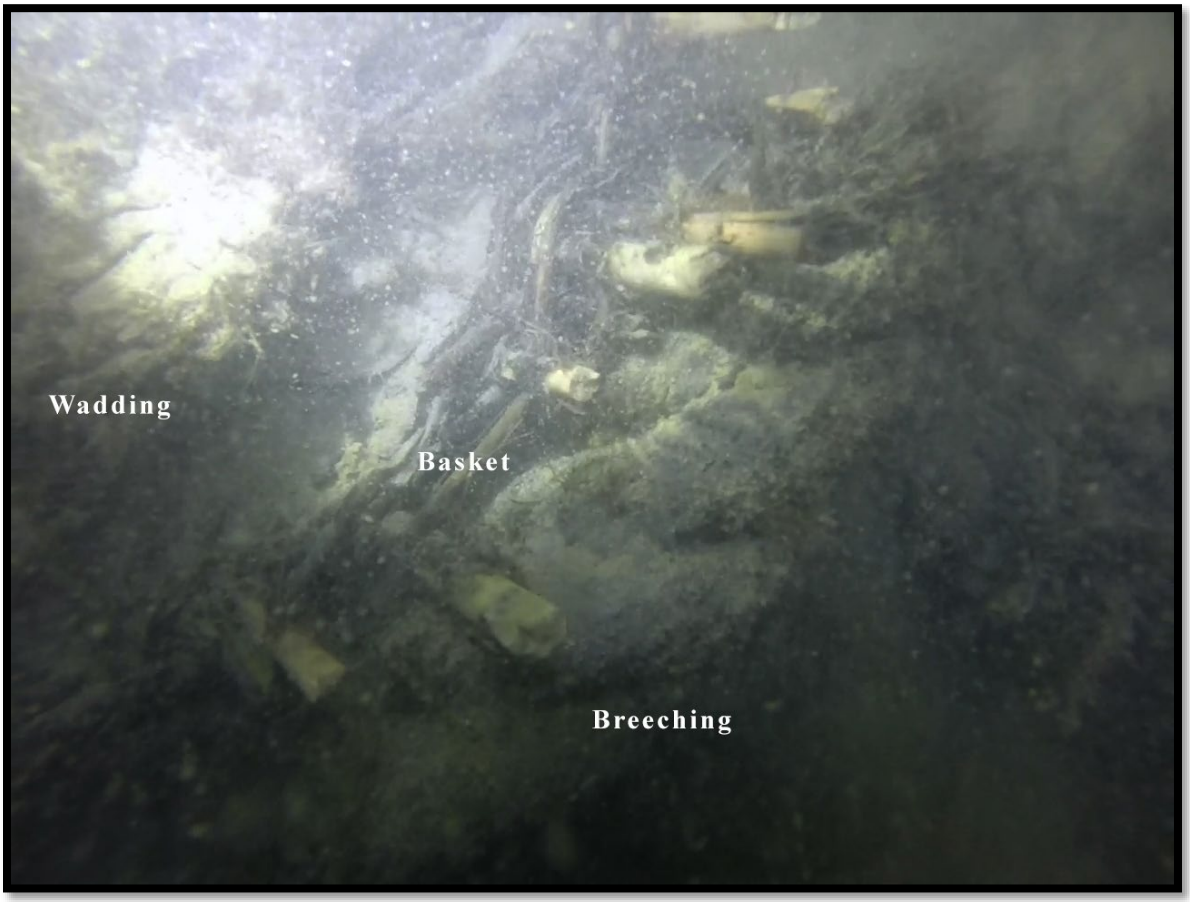

Figure 5.43: A still image taken from GoPro footage showing the edge of a wicker basket with wadding (Image by author).

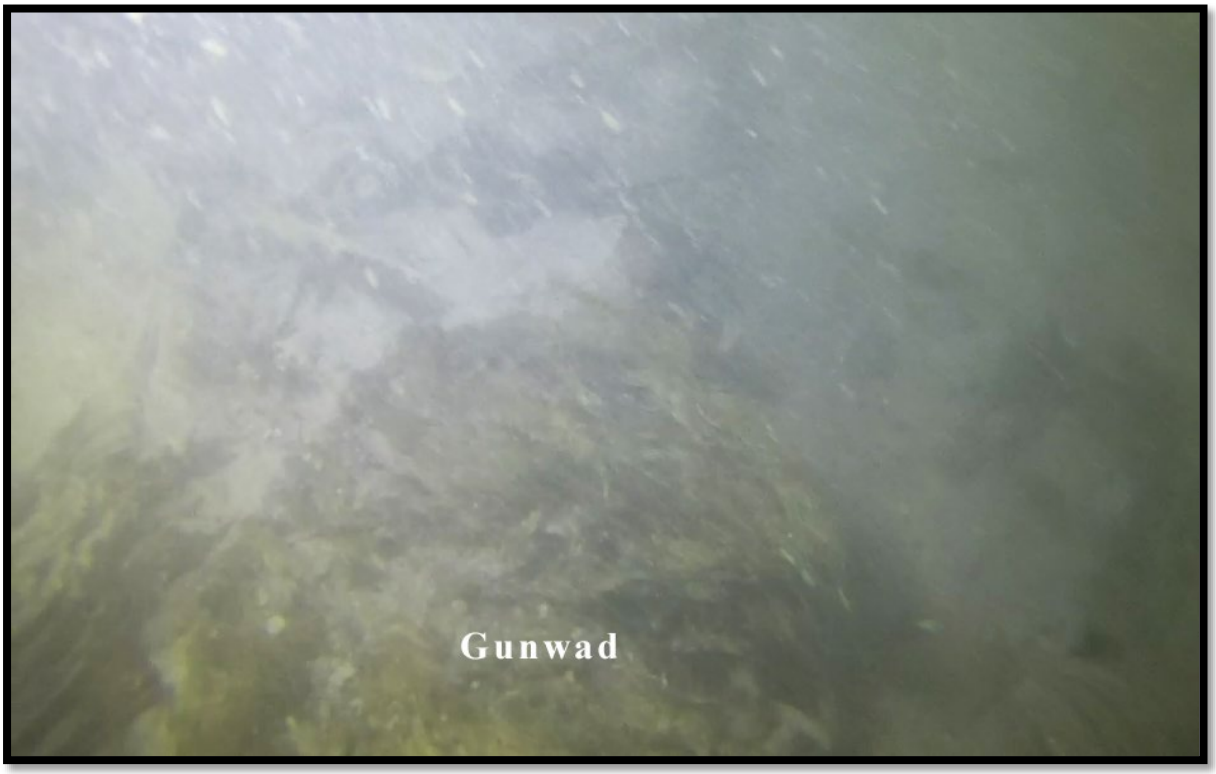

Figure 5.44: A still image taken from GoPro footage showing a gunwad, which was on top of a wicker basket (Image by Author).

Figure 5.45: Photo of gunwad **3479** (Photo by A. Middleton, HE).

Priming Wire and Linstock

The Chatham ledger lists priming wires as priming irons and there were 30 issued to the ship along with 30 linstocks (TNA WO55/1667). This is considerably less than the number of guns and suggests that the job of priming and firing the gun was in the hands of a select number of individuals, known as gun captains, whose responsibilities covered several guns at a time.

A single priming wire **3715** was found on the west side of Trench 3, during the 2016 excavation season, in the stratigraphy above the leather bandoliers and wooden powder boxes. It is made of copper alloy and is 400mm (15.7in) long with a diameter of 2-3mm with a loop at the top end, which is twisted back around the shaft, the lower end is pointed (Figure 5.46).

Figure 5.46: Photo of priming wire **3715** (Photo by author).

During the 2015 excavation season nearly the entire complement of linstocks was recovered from Trench 3. The linstocks were fragile and most were recovered in several pieces. A total of 29 individual linstocks were recovered in the form of: three complete and unbroken, nine complete but in fragments, eight nearly complete, and nine partials. They are similar in form but not identical (Figure 5.47). Bar one (**3310/3213**, which is in two pieces), they have all been turned from a single piece of wood on a lathe, which would have taken a great deal of skill in order to create the narrow shafts. In contrast, **3310/3213** has been carved rather than turned and has a style like those of the *Mary Rose* (Figure 5.48). With the exception of **3310/3213** they all have a hole at the head end for clasping the slow match. The head end is separated from the shaft by a collar. The lower end of the shaft has been turned to include a grip. At the end of the grips were small concretions or rust-stained holes. This was the evidence for a small iron spike, which was used to secure the linstock to the deck or bucket of sand when lit but not being used (Martin and Parker 1988, pp. 200–201, Hildred 2011, p. 490). X-radiography of the grips identified that the spikes were inserted into a pre-drilled hole extending up into the grip (Figure 5.49). They would have to have been pre-drilled otherwise the end of the grips would have split when driving the spike in. The linstocks have been made from a variety of woods including ash, birch, sweet chestnut, popular/willow and oak (Hazell and Aitkin 2019, pp. 32–35).

Figure 5.47: Photo of an example of the linstocks recovered from Trench 3 (Photo by author).

Figure 5.48: Photo of linstock **3310/3213**, which is hand carved as opposed to turned on a lathe (Photo by author).

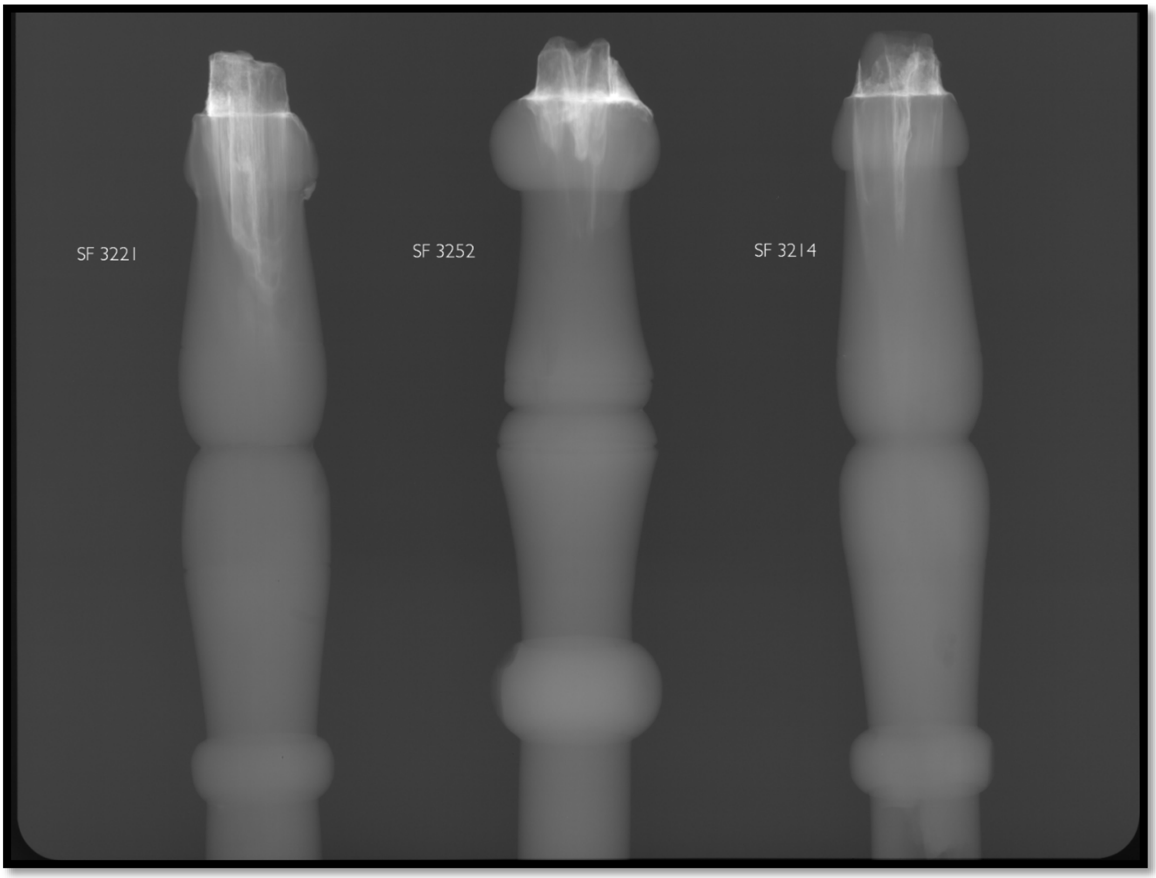

Figure 5.49: Radiography of linstocks **3221**, **3252** and **3214** showing the remnants of the iron spike at the bottom end of the grip (Radiograph courtesy of A. Middleton, HE).

5.4 EVIDENCE FOR THE SUPPLY AND USE OF THE GUNNERY SYSTEM

As only a small proportion of the wreck has been revealed through excavation and underwater conditions make it very difficult to fully understand the composition of the site, it is difficult to produce definitive interpretations of the various facets of the *London's* gunnery system. Aspects of the wreck would have also been inevitably lost during the catastrophic wrecking event and through the subsequent degradation over the last 350 years. Despite this, however, the excavations revealed the survival of intact and artefact-rich areas, relating directly to the gunnery system. Alongside the partial archaeological evidence is also an incredibly informative historical record relating directly to the *London,* extending from the year before to the weeks and days leading up to the loss. By combining the archaeological and historical evidence it is not only possible to identify the supply of gunnery related material but it is also possible to construct working hypotheses about the management of the gunnery system on board before the loss of the ship.

5.4.1 *Shot*

Supply

The Chatham ledger reveals that the *London* was issued with several types of shot, all of which were specifically designed to cause maximum damage to specific areas of a ship or personnel. The type of shot changes little during the late 17th and early 18th century, as a result the types of shot will be described and analysed in greater detail in the next chapter where the actual shot from sites has been recovered and examined. In this chapter the shot will be studied from the evidence of supply and subsequent use recorded from the issues and returns columns from within the Chatham ledger.

By looking at the supply of shot to the *London* during the ship's last year it is possible to build an understanding of how active the ship was at using the great guns. Inspection of the Chatham ledger shows that only a low percentage of round shot was expended, especially for the largest guns, during Montagu's command between June 1664 and February 1665 (Table 5.4). This was a period when there was not an official conflict but there were genuine hostilities between England and Holland, which would erupt by the end of 1664, so one would not expect the guns to be used as frequently as in times of war. However, the records in the ledger show how little practice there was in the use of the guns, especially with the largest guns on the lower tier. Practicing would have maintained skills among the gun crew, potentially leading to a more efficient and effective gun drill.

Date of issue & return	Number of round shot per gun type				
	Demi-cannon	24-pounder	Culverin	Demi-culverin	Minion
Iissued 7th June1664	640	320	1040	960	
Returned 20th Feb 1665	636	320	1000	900	40
Returned 23rd Feb 1665	636	320	1000	900	40
Total used	**4**	**0**	**40**	**60**	**0**

Table 5.4: Showing the number of round shot expended between 7th June 1664 and 23rd February 1665.

Use

The culverins and the demi-culverins were fired the most, sharing 100 shot between them. The demi-cannon were only fired four times and the 24-pounder and minions were not fired at all (Table 5.4). At this time a clear training regime was laid down in general instructions to captains, which stated that during the first month at sea the guns would be exercised twice a week; during the second month, once a week; and thereafter one every two months. Each exercise would consist of a maximum of six firings (Davies 2008, p. 143 quotes from NMM ADL/A/4). According to this general instruction, in eight months at sea the *London* could have potentially fired 120 shots. The Chatham ledger shows the expended shot of the *London* was 104 in eight months, which is below the maximum number of practice firings (TNA WO55/1667). From this evidence gunnery practice is shown to be conducted with the use of only a few guns, using only round shot and, on the *London,* that was mainly limited to guns on the second and upper tier. This suggests that gun crews must have taken it in turn to fire the guns. This limited form of practice would not have accurately simulated the use of the guns in a fleet or ship-to-ship engagement, when all or at least the guns on one side of the ship would be firing one after the other. In fact, the historian David Davies suggests the general instructions were deliberately introduced to limit the usage of powder rather than improve the performance of the gun crews (Davies 2008, p. 143).

Only four shots were fired from the main gundeck during Montagu's entire commission (Table 5.4). This may have been a powder saving measure or an indication that the *London's* lower tier ports were perilously close to the waterline and therefore could only be used in calm conditions. This was a common fault in the largest ships in the navy (Fox 1980, p. 20, Davies 2008, p. 40), which would have been exacerbated by the weight of extra guns issued to many ships at this time but was considered acceptable for ships operating in home waters during the summer (Davies 2008, p. 40). By 1664 the *London's* armament increased from 64 to 76 guns (Winfield 2009, p. 27, Fox 2011, p. 26) and this would have added considerable weight to the ship. In response to the extra weight, six inch thick girdling was applied (Fox 2011, p. 26), but the lack of use of the lower tier guns could suggest it may not have had the desired effect. This was a common problem in English ships as demonstrated during the Four Days Battle in 1666 when they had to keep the lower tier ports closed and heaviest armament out of action (Lavery 1981, p. 12).

The archaeology recovered from the *London* certainly supports a lack of use of the largest guns. The evidence from the rammers shows little evidence of wear around the ramming face and sides, especially on rammers **3801** and **3802** (Figures 5.50 and 51) - the rammers that were altered to fit the 24-pounders. The cut marks on both rammers look fresh with defined edges, not what one would expect if they were well-used pieces of equipment that were yielded to ram heavy objects down solid bronze barrels. The lack of wear and therefore use corresponds with the ledger that identifies that no 24-pounder round shot was fired. Rammers

3206 and **3207** do not look particularly well used either. Again, there is little wear around the edges of the ramming faces and the cut marks are still fairly clear on the edges of rammer **3207;** this is no surprise if the guns were only fired on average twice in eight months. The combined evidence from the *London* demonstrates that there was little practice in the firing of the guns.

Figure 5.50: Photo of rammer head **3208** showing clearly defined cut marks (Photo by author).

Figure 5.51: Photo of rammer head **3801** showing no signs of wear around edges of the ramming face and also wood worm holes suggesting it was sitting around not being used (Photo by author).

Lack of practice with the great guns would have had a knock-on effect with the rest of the management of the gunnery system. For instance, regarding the supply of the gunnery system there would have been a lack of practice with filling of powder charges and therefore the transference of gunpowder from barrels to cartridges. Although this could be seen as safe practise by limiting time spent handling a dangerous material, if you are not well practised in the routine of handling gun powder, negligence is more likely to occur. As the loss of the ship was caused by a huge explosion, there is a strong case for this negligence.

Poor practice can also be witnessed elsewhere: if there is a lack of use and turnaround of shot then the storage of shot would potentially have been rusting in the shot lockers. If the gun accessories were not being used regularly then there was potential that equipment could rot in the damp conditions or become infested with wood boring insects. This may explain the woodworm holes on rammer **3801** (Figure 5.51). Depending on the extent of the woodworm damage it could have seriously weakened the structure and strength of the rammer. Ramming a heavy object such as a cast iron 24-pounder round shot or even heavier, double headed shot, could cause the rammer to break on impact with the shot. This would have had serious ramifications if this occurred during battle. For example, it would hinder the gun crew's ability to load the gun until an alternative was found. The alternative would likely to have been a rammer on the end of a solid stave. These were shared between several guns, so may not be at the immediate gun station. Due to the length of the staved rammer the loader loses the ability to the load the gun fully within the safety of the hull. The staved rammer would have to be passed out through the gunport first and then pushed down the barrel of the gun. To perform this exercise the loader would have had to have partly leaned or placed his arms and shoulder area out of the gunport, directly exposing himself to enemy fire.

5.5 EVIDENCE OF ORGANISATION AND MAINTENANCE OF THE GUNNERY SYSTEM

An important factor that would have affected the management of the gunnery system would have been the familiarity of the crew with the ship. Prior to the *London* coming into Chatham dry dock in February 1665 it had been commissioned as a flagship under the command of Admiral Edward Montagu, Earl of Sandwich, patrolling with the Fleet in the English Channel. That commission started in June 1664, so it had spent nearly eight months on duty before it came into Chatham for cleaning, ballasting and provisioning, with an interlude at Portsmouth in November to change the Master Gunner and collect specific gunner's stores that were wanting (TNA WO55/331). When hostilities flared up again with the Dutch by the end of the year and war was imminent, Montagu was assigned a new flagship, the *Royal Prince* for the inevitable campaign against the Dutch. This led to the command of the *London* being transferred to Vice-Admiral Lawson. Montagu took his crew from the *London* and Lawson brought many of his own crew but also a number of pressed men (Fox 2011). Consequently, the new crew, including another new Master Gunner, Richard Hodges, would have been less familiar with the ship, which may be a contributing factor to its loss and also explain the distribution and cluster of artefacts discovered during the excavation of Trench 3.

Richard Hodges, the new Master Gunner, would have been responsible for signing for the gunner's stores coming back on board the ship of the 23rd February, so was on board before the others arrived when the ship was re-floated. It would therefore have been his responsibility to assure all the powder was safely stored, that the guns were all sufficiently equipped, spare equipment and hand weapons were stowed. This would have been a considerable amount of work, but considering the stores went back into the ship on the 23rd February and ship blew up on the 7th March there was ample time with a competent crew to have everything stowed correctly.

When the *London* left Chatham on the 7th March, Lawson and other Officers were not yet aboard. The *London* was making its way from Chatham to pick up Lawson and other Officers and crew at a place known as the Hope, a short distance up the Thames (Anderson 1929, p. 171, Fox 2011, p. 15). Historian Frank Fox suggests at the time the *London* blew up there was no one higher than a Warrant Officer on board (Fox 2011, p. 18). The combination of a lack of authoritative figures and unfamiliar crew could potentially have been a contributing factor to the loss of the ship. As the probable cause of the loss was due to negligence in the main magazine, heavy scrutiny must be placed on the leadership and ability of Master Gunner Richard Hodges, who at the time of the loss would have been one of the Warrant Officers on board. During the 1650s and 60s the Master Gunner was considered to be an esteemed position and should the commissioned Officers and Master be killed in action then the Master Gunner would take command of the ship (Davies 2008, p. 102). The identity of the *London's* Master (also a Warrant Officer) has yet to be identified (Fox 2011) and it may be the case that he was not on board yet. If he was not on board the Master Gunner Richard Hodges may have been in charge of the ship.

So, what evidence can be gleaned from the archaeology that can enable one to scrutinise the abilities of the Master Gunner? By attempting to understand the distribution of objects, predominately the ones found in Trench 3, one can attempt to explain the efficiency of the organisation of the gunnery system and also the ability of the Master Gunner.

Of the stores listed in the Chatham ledger, a certain proportion would be distributed to each gun on all tiers for immediate use, and spare equipment, munitions and powder would have been stowed in designated storage areas around the ship. For example, the spare gun equipment would have been stored in the gunner's store on the platform deck in the bow; hand weapons, according to Francis Povey, were stowed in the gun-room and Great Cabin; the main supply of shot would have been amidships in the hold, fore and aft of the mast; and powder in the magazine, in the forward part of the hold. One would normally expect the equipment and stores to be stowed and organised before the ship leaves port and each gun station should have been equipped with the necessary accessories for operating the guns. The findings of multiples of the same equipment at a single gun station, along with other equipment, hand weapons and hand weapon accessories that should have been stowed away leads one to consider that there were issues with the management and organisation of the gunnery system. As there were no Officers on board that responsibility must fall on Master Gunner Richard Hodges.

The excavation of Trench 3 and the prior recovery of the gun demonstrated that the gun was in place and secured with breeching and gun tackle, adjacent to the gunport. It is highly likely that all the guns were secured before going to sea as, weighing between 2-3 tonnes each, if loose could cause serious damage to the ship and injury to the crew. However, one can see from the numbers and types of other artefacts from the trench that the preparation for sea was far from complete. Let us assess the significance of the number and type of certain artefacts found at this main gundeck gun station.

It has been established that the guns on the broad side would have had one hand crow leaver each for traversing the guns from side to side, but the archaeological evidence recovered from Trench 3 has identified 20 crow levers with several more left in-situ on the deck. It would perhaps be easy to explain one or two extra hand crow leavers, which could have moved to this location during the wrecking event, but to have over twenty assembled in neat layers either side of the carriage suggests they were deliberately put there. There is a possibility that these were spare and therefore they were placed by this gun station temporarily before being stowed below in the gunner's store. However, as there are over twenty this seems too many to be spare and with only 63 recorded in the ledger this would have meant far more guns sharing this quite essential piece of equipment. It is more likely that they were placed at this location temporarily before being distributed to the other guns on the deck.

Regarding the rope sponges, it has been established that each gun would have been equipped with one rope sponge (rammer and sponge heads at either end of a stiffened rope) each. So as Trench 3 is the location of a 24-pounder gun one should expect to find one rope sponge to fit the bore of the 24-pounder. Instead, two rammer heads and one sponge head with the remains of sections of their rope were found. The size of the rope holes and ramming faces for each head differs, suggesting they do not match with one another. The sizes of the rammer heads are more suitable for a culverin or a demi-culverin. The demi-culverins were found two decks above and the culverins were found predominantly on the second tier above or at the stern chase ports. Site 2 is unlikely to be part of the stern as the stern remained partly above water after the explosion and this is believed to be the location of Site 1. Therefore, one would not expect culverin equipment on this part of the main gundeck if it were correctly distributed. The sponge head would be suitable for a drake of culverin and above. There is potential for this sponge head to fit the 24-pounder gun but none of the 24-pounder recovered have a tapered bore that is a feature of the drake. Rammers **3801** and **3802** would be ideal candidates for the gun at this position, however, they were found together and among others in a close but different area of the gundeck. The various sizes and the groupings also suggest that these rope sponges had not been distributed to their appropriate guns.

Twenty nine of the 30 linstocks recorded as being issued to the ship were found grouped together close to the carriage. The number of linstocks demonstrate the responsibility of firing the guns was in the hands of a few and that those persons shared a linstock between several guns. One would expect either the Master Gunner to store them possibly with him, in his quarters, in the gun-room at the stern, or in the gunner's store at the bow, or to have sufficient numbers placed between the guns on each gundeck. Finding nearly the whole quota of linstocks at one gun station shows they were not stowed away or distributed evenly between the gun decks.

As well as finding equipment relating to the operation of the great guns, the excavation of Trench 3 also revealed a broken chest containing leather bandoliers with dozens of wooden powder boxes. The bandoliers were leather shoulder belts punched with a series of holes for suspending the wooden powder boxes and a primer. The powder boxes contained a single charge of powder to load a musket or pistol. The primer was a powder box with a spout instead of a lid and this was used to prime the weapon. Each bandolier suspended 11 powder boxes and one primer. The ledger records that the *London* was issued with 70 bandoliers (WO55/1667). A butt of a pistol was recovered from below the bandoliers with the likelihood that there were originally others. With the exception of the gun-room at the stern it is extremely unlikely that bandoliers holding boxes of powder charges and hand weapons were stored besides a gun on the main gundeck; it would have been extremely dangerous to have containers with loose powder at a location that could be exposed to gun fire. Hand weapons such as muskets and pistols along with their powder and charges would have been stored in a reasonably secure place but which was also accessible for immediate use, such as the gun-room or a the Great Cabin as Povey states. As with the gun's equipment it would appear that the hand weapons and accessories were not all stowed as they should have been.

The archaeological evidence found in Trench 3 and other areas of the main gundeck clearly demonstrate that a significant proportion of the gun's accessories were not evenly distributed. Other gunner's stores such as hand weapon accessories were also not stowed away in a safe or secure place. All of this equipment was the responsibility of Master Gunner Richard Hodges and it would have been up to him to ensure that this equipment was stowed and correctly distributed. Considering twelve days elapsed between the time the stores came on board and when the ship blew up there would have been sufficient time to distribute the equipment to its correct places. The fact that this had obviously not occurred, or was still in the process, shows a lack of organisation and professionalism by the Master Gunner as well as the other Warrant Officers, who were in charge of the ship until the Captain and other Officers came aboard. There may be several contributing factors that did not help the Warrant Officers: there were no Officers on board to ensure that work was being conducted efficiently; the crew were unfamiliar with the ship, although the layout of warships would have been quite similar and therefore this should not really be an excuse; there was a proportion of pressed men, whom may not have been competent; and there were an unknown number of women on board, suggesting the ship was not functioning under strict routines.

5.6 KEY POINTS

There are several key points to summarise from the results chapter on the *London* and which will be expanded in more detail in the discussion chapter. They are as follows:

1. The ship, or at least the finest ships in the fleet, were perceived as symbols reflecting the status of the State, later the Crown and even high-ranking Officers. This was demonstrated through the *London's* elaborate stern and bow carvings and her arming with a fall arsenal of bronze guns.
2. The bronze armament was at a cost to the *London's* overall weapons capabilities.
3. The issuing of nonstandard guns led to existing equipment having to be adapted rather than designed specifically for those guns.
4. The shortage of appropriate bronze guns also led to a greater mix of gun types on the main gundeck, which could have led to potential issues supplying those guns with the correct powder and shot in pressured situations.
5. The increase in the number of guns issued to the *London* is an example of the administration's habit of over gunning their ships.
6. The placement of extra guns at the stern and forward facing ports did not suit the new fighting tactics, demonstrating a lack of communication and understanding between the naval administration and the new tactics of their serving commanders.
7. The archaeological evidence has highlighted a lack of discipline and professionalism on board, which has been demonstrated through the quantity and types of stores found at one gun station.
8. The study of inventories alongside the archaeological evidence has identified a lack of use of the great guns and therefore a lack of practise in their operation.
9. Overall, the type of gun equipment had not changed significantly from the time of the *Mary Rose*, instead it was adapted to better suit sea service and use in confined spaces. This led to more functional and standard designs compared to the equipment found on the *Mary Rose*.

10. There is an obvious wish to standardise equipment to simplify production and supply but this was not strictly followed which is evident from variety of wood species identified to make the same objects.
11. The *London* has provided the earliest evidence of the rope sponge and inventories show this was one of the essential pieces of equipment issued to all guns. It reflects the new fighting tactics and the need to be able to reload the gun from within the safety of the hull.

Chapter 6 The *Hazardous* (1699 – 1706)

6.1 INTRODUCTION TO THE *HAZARDOUS* RESULTS

The focus of this chapter will be on the archaeological evidence from the *Hazardous*, lost in 1706. The general period under investigation, however, begins much earlier, following the end of the third Anglo-Dutch war in 1674. This chapter will therefore include evidence from other shipwrecks, historical and iconographic data spanning this entire period.

6.2 INTRODUCTION TO INVESTIGATIONS ON THE SITE OF THE HAZARDOUS

This section combines the records collected by the Hazardous Project Group (HPG) since investigations began in the early 1980s with those results gathered since 2014 during the author's involvement as the site's nominated archaeologist. There have been small excavations on the main site in 1988 and currently ongoing since 2017. However, the most recent have been minor due to interruptions caused by logistical and adverse weather conditions. Much of the results contained in this chapter have come predominantly from un-excavated in-situ observations made by the author and other team members. Past observations were recorded in dive logs, which the author has collated and studied for this research. Current observations have been made possible as the result of natural exposure during periods of seabed loss, caused, initially, by the migration of sand moving away from the site. Once the wreck is exposed, its shallow depth exacerbates the problem, with wave action causing further scour during high energy sea conditions. The site is therefore being excavated naturally due to the dynamics of the underwater environment.

The HPG have been diving *Hazardous* every year since investigations began and have observed that the site has experienced several cycles of exposure and reburial, with its current period starting in 2013. Since then the reductions in seabed sediments have exposed parts of the surviving port side structure, from the bow to approximately amidships, and from the main deck down to the keel. During current and past periods of exposure, the surviving structure has acted like a bowl, containing sediment inside the wreck. Over time, however, the level of sediment has steadily washed out, exposing new artefacts and internal structures. Many of these exposed artefacts are related to gunnery and, once recorded in-situ, have been recovered for conservation and study. Unfortunately, not all exposed artefacts were able to be recovered. This has particularly been the case for larger artefacts, such as gun carriages, which were still attached to their corresponding gun. Despite their subsequent degradation, the recording of these carriages at the time of their original exposure has meant information was not completely lost but has contributed critical information on how the guns were mounted and secured. This will be discussed in greater detail in section 6.3.1.

During the most recent period of exposure, two additional areas of the site were discovered. First, in 2014, a group of 11 guns were found 115m west southwest of the main site and then, in 2019, another group of 10 guns were located 110m west northwest. In 2020 further material, including significant clusters of round and bar shot, were found to the southwest of the 2019 guns, extending the boundary of that area. From this point forward these sites will be referred to as the 2014 and 2019 gun sites (Figure 6.1). It is also worth mentioning that an isolated gun lies 26m to the west of the 2019 gun site gun and 88m northwest of the main site. The size of gun is consistent with the *Hazardous'* upper deck guns. As well as guns, other artefacts were found in both locations, including scatters of iron shot. The spread and location of material suggests the wrecking was not one single event but a series of groundings, resulting in the loss of heavy objects, followed by drifting, before finally coming to rest at the location of the main site.

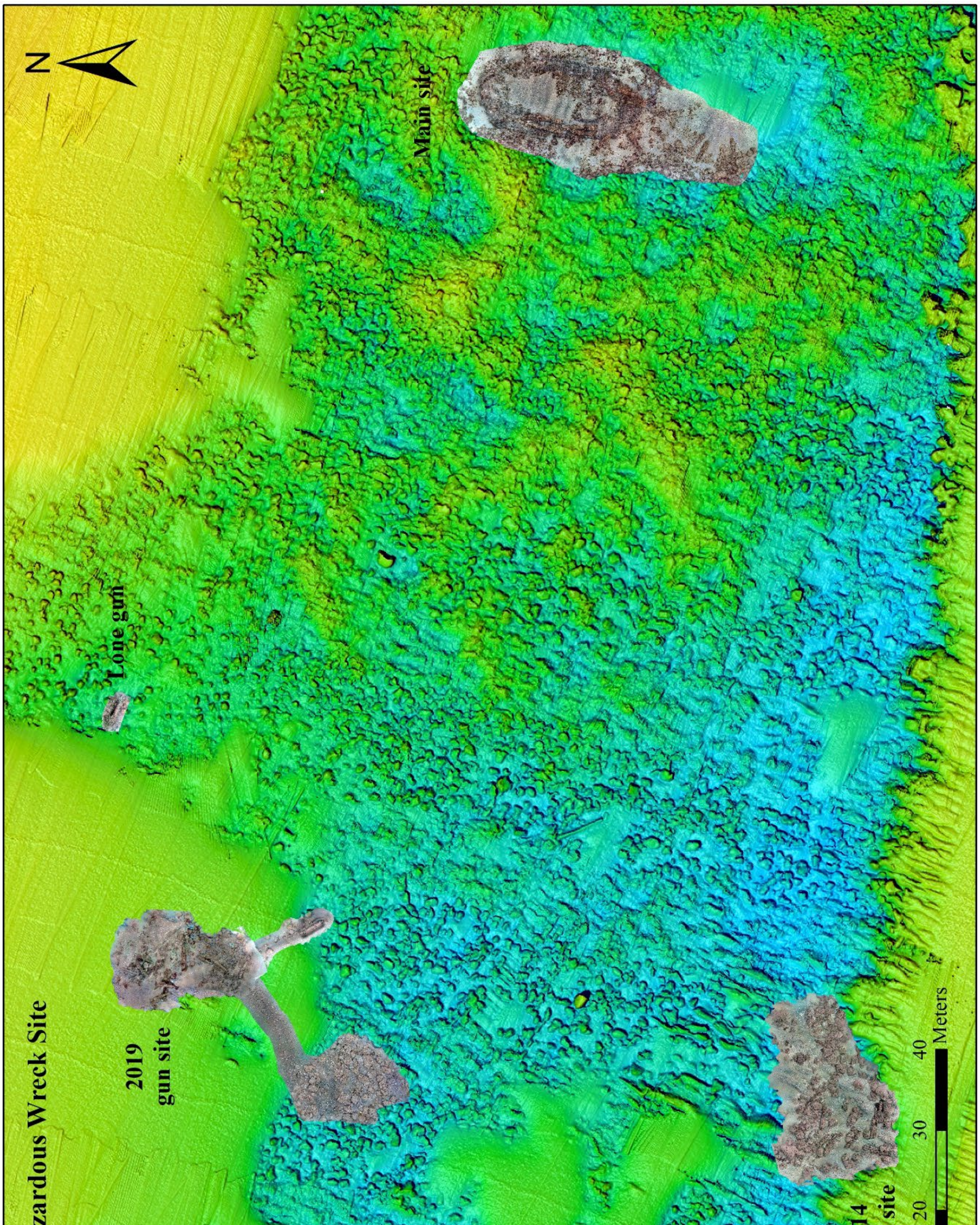

Figure 6.1: The 2020 multi-beam bathymetry of the *Hazardous* wreck site showing georeferenced orthophoto mosaics of the known areas of the site (Multi-beam courtesy of HPG, image produced by author).

The following sections, 6.2.1 – 6.2.3, will introduce the three areas of the site and explain which part of the *Hazardous* and the gunnery system they relate to. Sections 6.3– 6.4 will then discuss the evidence found on the site for operating the guns and for the organisation and maintenance of the gunnery system. Evidence from other archaeological sites of the time will be incorporated throughout, as well as contemporary historical sources and iconographic data. Finally, section, 6.5 will be a summary of key points.

6.2.1 *The Hazardous main site*

The main site currently consists of one coherent section of the port side, which extends longitudinally from approximately amidships, forward to the remains of the cutwater at the bow, and vertically from the partial remains of the main gundeck down to the keel (Figure 6.2). The original site was larger, but exposure during the winter of 1991 resulted in the loss of a 10m long section of hull structure, immediately south of that currently exposed. All that remains of this eroded section are the three guns that were once adjacent to it (Figure 6.2).

The bow points to the north with the remains of the gundeck on the west side and the keel on the east side. There are 11 guns, all located on the west side and roughly in a north - south line, seven of them (guns 7-13) are still connected to the surviving structure while the other four (guns 3-6) lie on the seabed to the south end of the wreck structure (Figure 6.2). Two guns were recovered in 1986 (Guns 1 and 2) and will be described in section 6.2.4. The orientation of the surviving structure shows that this section of the *Hazardous* healed over to the port side during the wrecking process. Guns 3-7 and 10 are orientated with their muzzles facing west, the same direction as the gunports. These guns are therefore likely to be from the port side batteries and were secured with their muzzles lashed above the port. Guns 8, 9 and 11-13 lie in a group on the remains of the gundeck with their muzzles facing the bow. Due to their grouping and orientation it is highly likely that some of these slid from the starboard side during the wrecking process. However, two of the guns with the remains of their carriages attached lie across the side of the port side and the gunports. These guns probably originate from the port side battery and were secured in this position intentionally, which was known as 'lashing alongside'(Harland 1984, p. 210). The securing of the guns will be discussed in more detail in section 6.3.2.

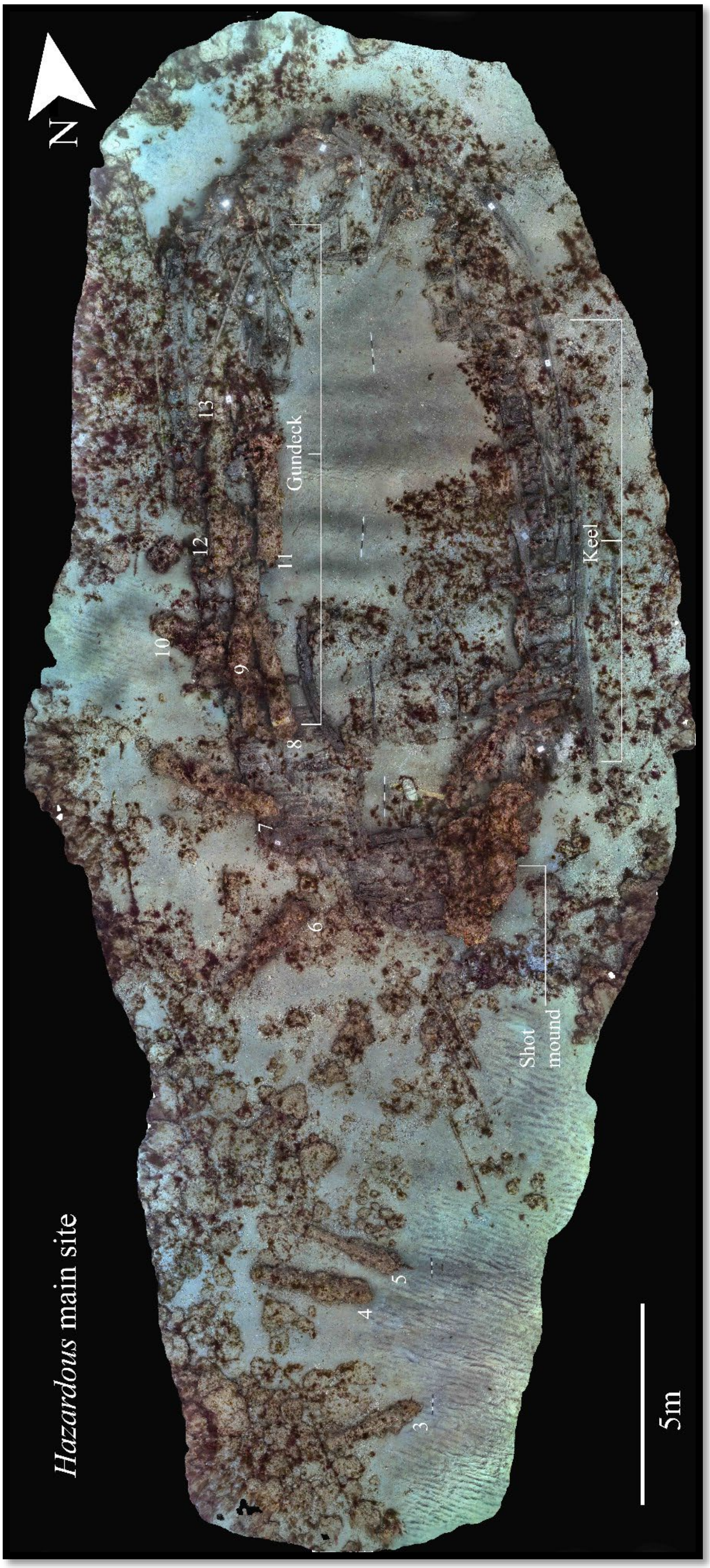

Figure 6.2: An orthophoto mosaic showing the current extent of the main site and the guns are numbered 3-13 (Survey and image produced by author).

6.2.1.1 Main gundeck survival

The main gundeck is clearly discernible because of the six 18-pounders (guns 7-13), which lie on the structure. The 18-pounders were the *Hazardous'* largest guns and 22 were originally housed on the main gundeck (TNA ADM106/586/285). The partial remains of the deck survives beneath guns 8-13, for a total length of 11m (Figures 6.2 and 6.3). The maximum depth of stratigraphy on the gundeck is found at the location of gun 13, which is situated on its side, partially buried but with the remains of one exposed cheek. Half the gun, the bed and other cheek of the carriage are buried - an indication that the depth of buried deposits is less than the width of the gun carriage and therefore under 1m deep. Gun 12, immediately aft, also has the partial survival of its carriage. Both of these carriages will be described in detail in section 6.3.1. Immediately below the five forward facing guns is the remains of the gundeck, a line of eroded ends of deck beams protrude from the sand, showing the extent of survival (Figure 6.3). A layer of deck planking is also evident but much of the surviving structure is currently obscured and inaccessible to detailed recording because of the guns. Guns 7 and 10 lie partly in and out of the surviving hull structure and they could mark the position of gunports. Forward of gun 10 are the remains of two gunports and their adjacent guns (12 and 13) lie with their chases across the ports with the muzzle facing forwards.

Figure 6.3: 2019 photogrammetry survey model showing protruding gundeck deck beams. The scales in the image are 1m with 20cm increments (Survey, model and image produced by author).

6.2.1.2 Hold and orlop survival

There is high potential for extensive areas of the orlop and hold to survive as the exposed parts of the wreck indicate that the port side is coherent in the forward sections, from the gundeck to the keel, but most of this area is currently buried. As the main gundeck beams, floor, and keel are exposed, it is possible to approximately discern where the orlop and hold are: at the south end and on the east side there is a shot mound that is 5.7m long by 2.25m wide by 1.5m high. It is currently located on top of the ceiling planks of the hold but would have been stored in shot lockers located forward of the main mast. Between the gundeck beams and the keel and shot mound on the east side is a sandy area, buried in which are the remains of the orlop and hold (Figure 6.1). This is where the greatest depth of stratigraphy is but the reducing sand levels in this area have exposed many artefacts associated with the ship's stores and provisions. Among the finds have been an array of spare gun equipment and accessories for transporting powder. The former would have been stowed in gunner's store rooms on the orlop (Winfield 2005, p. 71) and the powder accessories in the magazine or filling room, in the forward areas of the hold, just abaft the foremast (Winfield 2005, p. 73).

From the evidence currently exposed on the seabed it is possible to see that this section of the *Hazardous* contains evidence relating to most aspects of the naval gunnery system, from the storage and supply of shot, powder and spare equipment in the hold and the orlop, to the mounting and operating of the guns on the gundeck. A full-scale excavation of the main site would potentially produce a more complete understanding of the gunnery system but until then there is adequate evidence to form credible working hypothesises.

6.2.2 *The Hazardous 2014 gun site*

This area of the site is located 115m west south west of the main site. It consists of 11 heavily concreted cast iron guns (guns 14-24) and scatterings of round and double headed shot (Figure 6.4). Several lead scuppers were also found, which suggest some parts of the hull structure were lost here, and that the guns and shot were not simply jettisoned. At least one of the guns has the remains of its carriage, which also suggests the gun was not jettisoned on purpose. All the guns were heavily concreted, so it was not possible to gain precise measurements, however, based on the sizes of guns previously recovered and from known dimensions of guns of this period, it is possible to make an informed conjecture on the possible sizes of guns located here. The guns will be analysed in more detail in section 6.2.4 but for the purpose of this introduction the guns here would appear to be a mixture of 12 and

6-pounders. The 12- pounders were located on the upper deck and the 6-pounders were found on the quarter and forecastle decks (TNA ADM106/586/285). From the size of the guns and the lead scuppers, the 2014 gun site appears to have originated from a section of the *Hazardous'* upper structures.

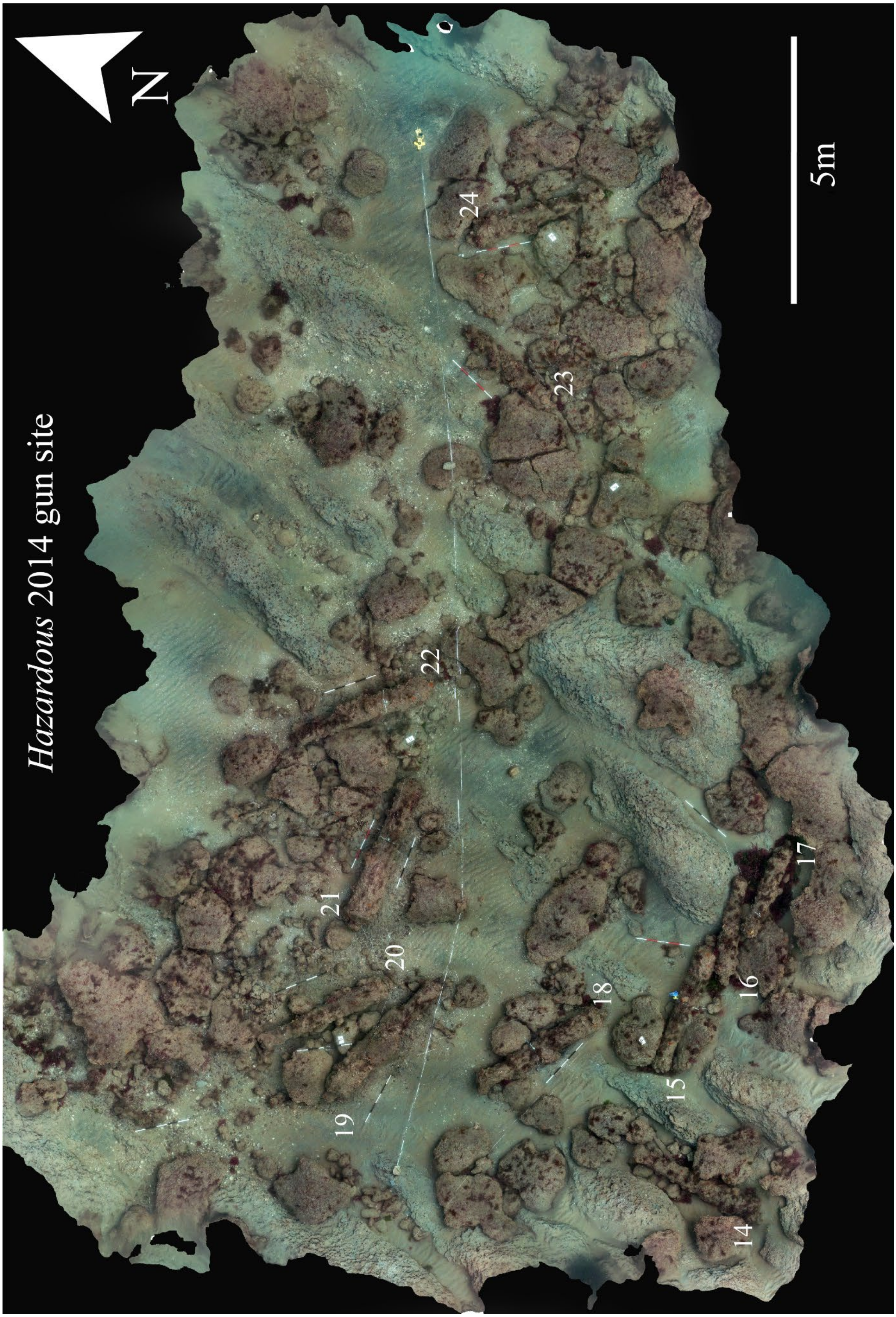

Figure 6.4: An orthophoto mosaic of the 2014 gun site. Guns are labelled 14-24. (Survey and image produced by author)

6.2.3 *The 2019 gun site*

This area of the site is located 110m west-northwest of the main site. There are 10 heavily concreted iron guns (Guns 25-34) with scatterings of round and double headed shot but, unlike the 2014 gun site, there is a much greater variety of other types of artefacts and features (Figures 6.5-6)[2]. These include an anchor, a large copper cooking vessel, a circular stone sharpening stone, a large single timber frame and scatters of small finds (Figures 6.5-6 and 6.35). There are also several concreted bolts close to several of the guns that may be the through bolts that secured the carriages. This suggest the guns went into the water on their carriages and were not jettisoned on purpose, with the variety and type of artefacts as well as timber structure further supporting this interpretation.

The sizes of the guns are consistent with the upper deck, quarter deck and forecastle, suggesting that this was the location of a broken section of the upper structures. The cooking vessel would be associated with the galley, found forward, and anchors tended to be stowed at the bow. So the artefacts and gun sizes would suggest this site was at least part of the upper and forecastle structures, which parted and broke away from the lower sections of the ship.

Despite there being little surviving structural evidence, the guns and the distribution of shot are potentially an indicator of the supply and organisation of the *Hazardous'* munitions and will be discussed in section 6.4.1-2.

[2] Gun 25 was located after the original survey and was later surveyed in relation to gun 26. It was not possible to merge the two separate surveys because Gun 26 had rotated slightly since the original survey.

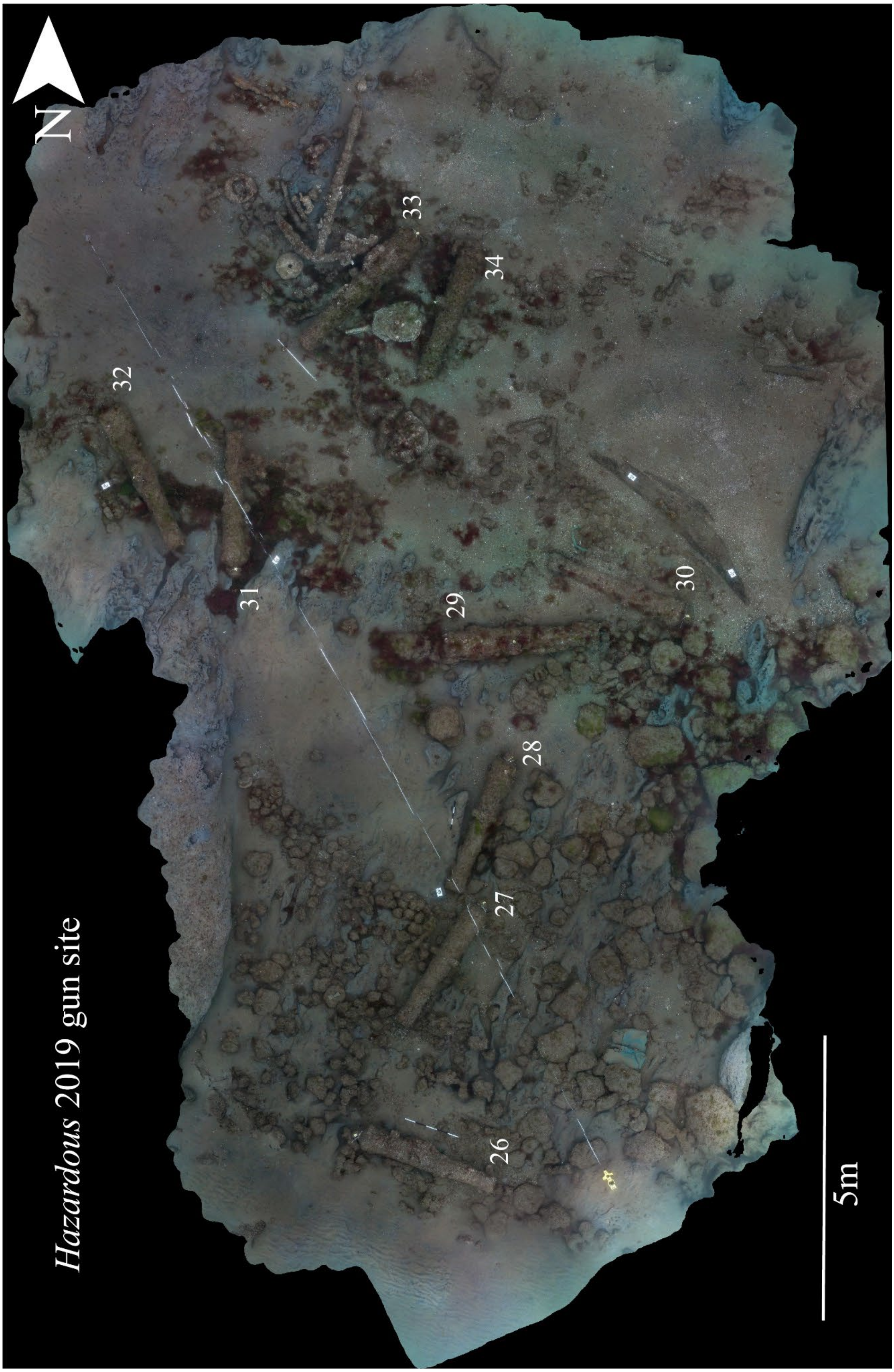

Figure 6.5: An orthophoto mosaic of the 2019 gun site. The guns are labelled 26 -34. Gun 25 was found later and lies a few metres outside this survey to SE. (Survey and image produced by the author).

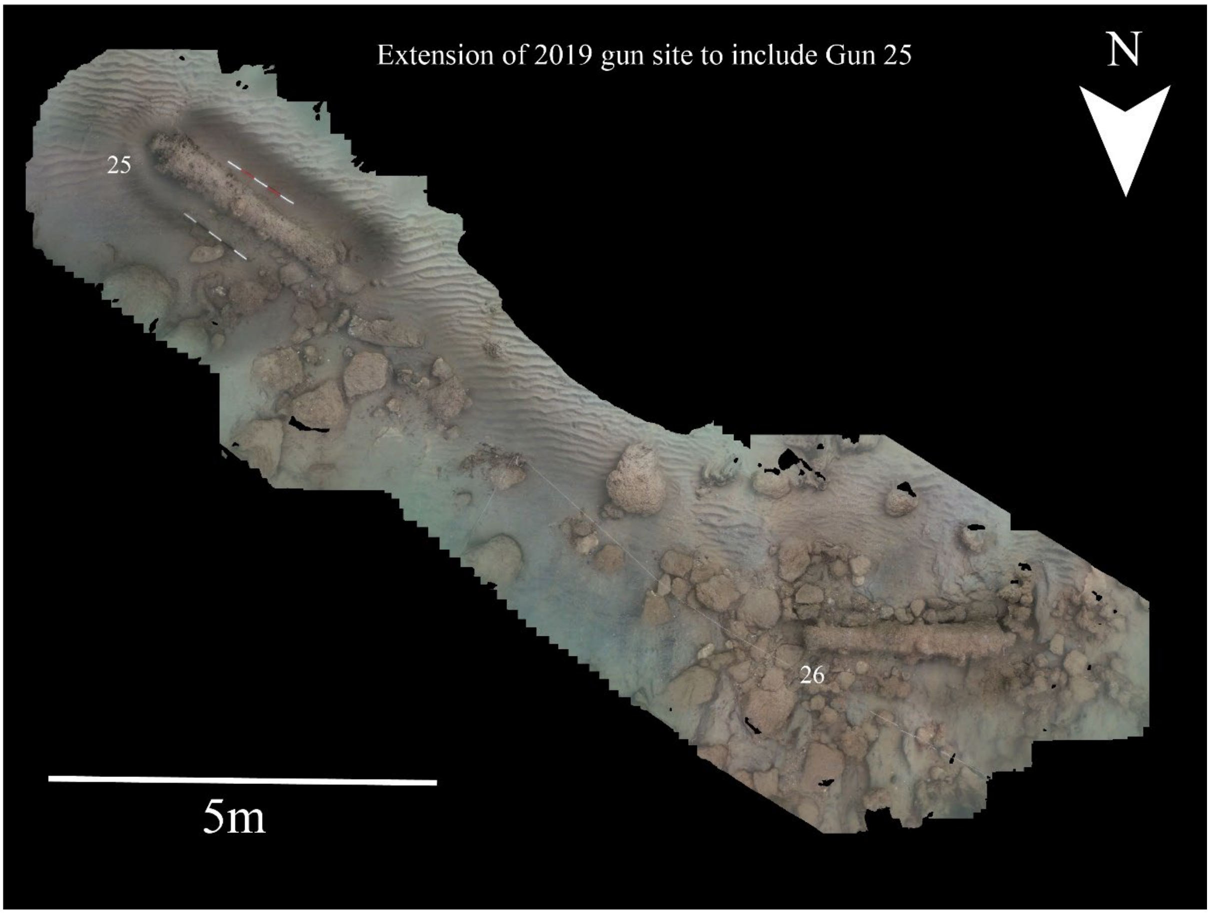

Figure 6.6: Orthophoto mosaic showing guns 25 and 26 of the 2019 gun site (Survey and image produced by author).

6.2.4 *The recovered Guns*

In 1986 two heavily concreted iron guns were recovered from the main site, de-concreted and recorded. They were both 12-pounders but of different lengths and even patterns (Figure 6.7). Critically they were not of an English type and were therefore assumed to be two of the *Hazardous'* original guns (Owen 1991, pp. 329–331). Recent historical research by the HPG discovered the historical evidence that confirmed that the *Hazardous* was re-issued with the guns the ship was captured with, but with the exception of one 18-pounder that was damaged. The initial survey of the ship was reported in March 1704 and showed that the *Hazardous* was armed with 50 guns but was in fact capable of carrying 60. It recommended keeping 49 of the original guns and completing her armament with three 18-pounders, two 12-pounders and six 6-pounders (TNA ADM106/594/45). This would have brought the armament up to 60 guns. However, a letter written on the 24th December 1704 by the newly appointed Captain, Barrow Harris, stated the number and weights of the guns on board. It specified that the *Hazardous* was issued with 54 guns: 22 on the lower deck, 22 on the upper and 10 split between the half decks (TNA ADM106/586/285). The HPG is grateful to ordnance specialist

Ruth Brown who recognised that the weights suggest foreign calibre guns. The archaeological evidence therefore suggests the guns on the seabed are the same guns the ship was issued with when commissioned into the Royal Navy. Understanding the origins of the guns is critical as the whole organisation of the gunnery system is based around them, from mounting and securing to supply and organisation of shot, powder, and equipment. There was a difference between French and English measurements of feet and inches, meaning bore sizes of guns differed, albeit by small increments. These small increments, however, could potentially have led to alterations to equipment and shot to ensure they functioned adequately with the guns. This will be discussed in section 6.4.

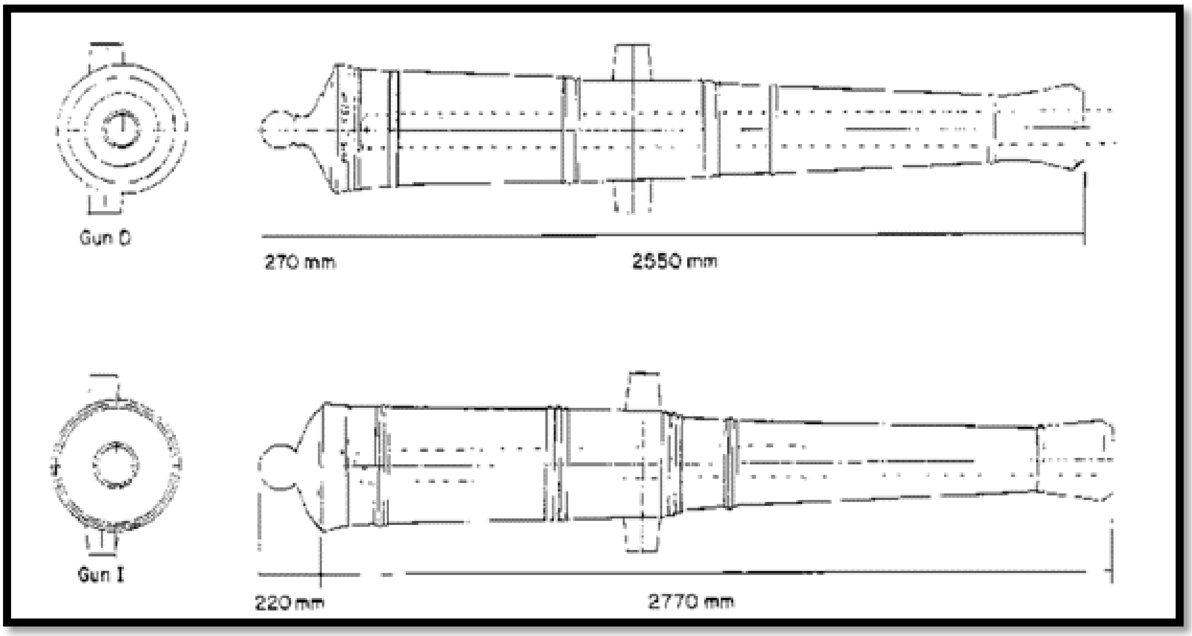

Figure 6.7: Drawing of the two 12-pounder guns recovered from the site in 1986 (Drawing courtesy of the HPG).

Another key piece of information from the historical record demonstrates that the wreck of the *Hazardous* was partly salvaged over several months and, by the 6th June 1707, it was reported that 21 guns and other gunner's stores had been recovered (TNA ADM106/625/145). A further six culverins were reportedly salvaged in 1715 (TNAWO47/28 and WO47/29), although there is reasonable doubt as to whether these were actually recovered from the *Hazardous;* nine years had passed since the wrecking and there are other wrecks in the Bay. If you add the current number of guns observed on the seabed including the two recovered in 1986 (35 guns) and the number of guns reportedly salvaged by June 1707 that makes 56 guns: two more than were issued in 1704. The additional six culverins possibly salvaged in 1715 would make 62. There is, therefore, some interesting discrepancies between the historical record and what has been currently found existing on the seabed, the investigation of which is currently outside the scope of this research.

6.3 Evidence for working the guns.

The current evidence for working the guns on board *Hazardous* comes from two of the 18-pounder guns and carriages found on the remains of the main gundeck, as well as the spare carriage and gun equipment, which have been found exposed on the surface in areas associated with the orlop and hold. Other supporting evidence from the period comes from the wreck of the *Stirling Castle*, a 70-gun ship of the line, which was lost on the Goodwin Sands during the Great storm of November 1703 (Perkins 1980, McElvogue 2008, Whitewright 2020). A demi-cannon, complete with carriage and much of its gun tackle, was rescued from the collapsing gundeck in 2000, by the site's Licensee, Robert Peacock (McElvogue 2008, Whitewright 2020). The assemblage will provide important complementary evidence on how the gun was mounted, secured for use during bad weather, and how it was loaded.

6.3.1 *Mounting the guns*

Regarding the carriages of this period little had changed in their design or construction from the example recovered from the *London*, with the possible exception of the front wheels appearing to reduce in size, as one will see. They are, therefore, what is defined as a truck carriage as described in the previous chapter. The two carriages recorded on the *Hazardous* are as one would expect: truck carriages, but they have visible characteristics that shows they were not of the British style. This section will analyse the carriages recorded on the *Hazardous* and then compare the difference with the carriage recovered from the *Stirling Castle*.

The *Hazardous* carriages

The remains of two carriages were found attached to their 18-pounder guns on the forward section of the gundeck (Figure 6.8). The one attached to gun 13 was more complete than the one attached to gun 12 and will be described first. [3]

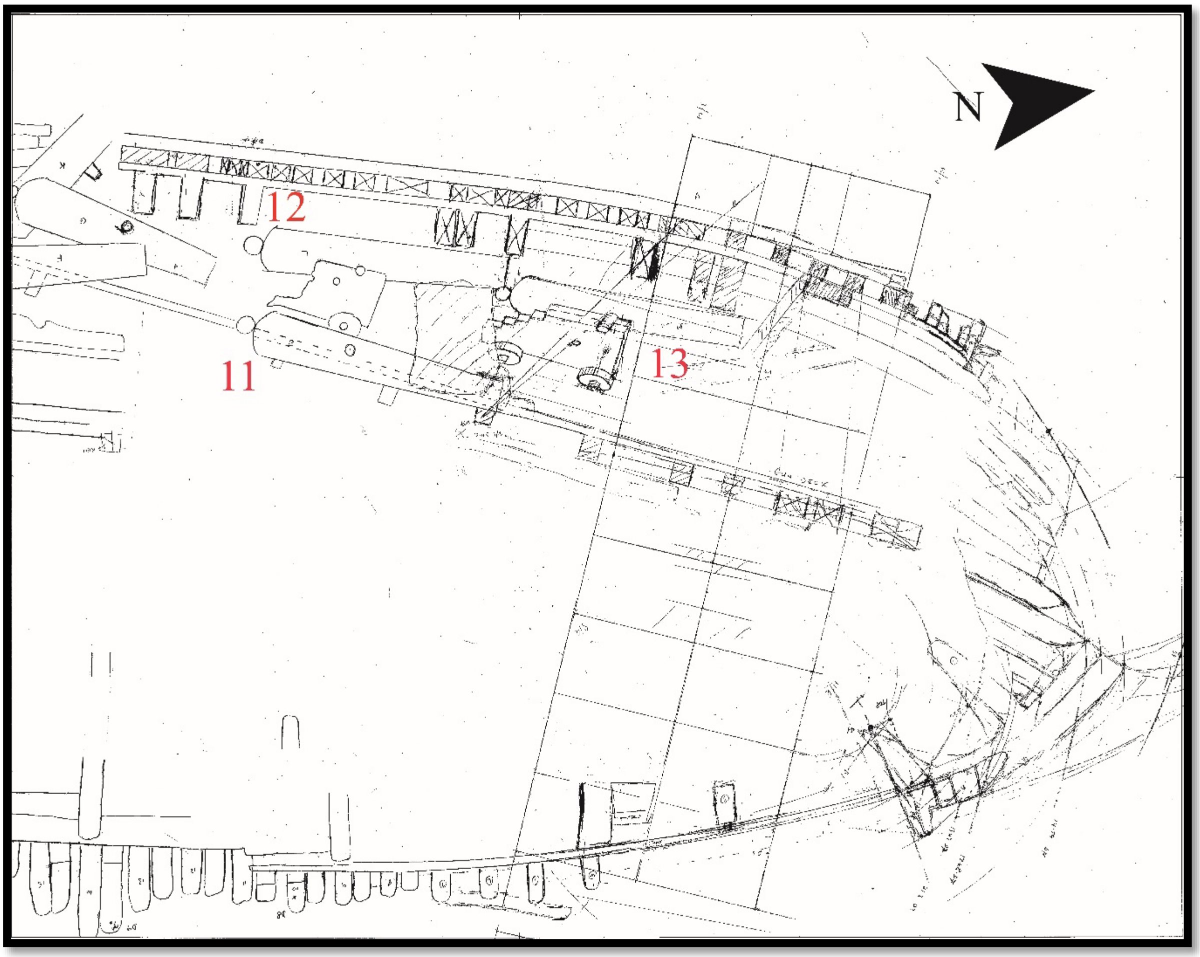

Figure 6.8: The forward section of the 1990 site plan showing the remains of two gun carriages attached to guns 12 and 13 on the main gundeck (Plan courtesy of HPG).

Gun 13 was recorded lying on its side with the right cheek and the right side forward and rear trucks exposed. Much of the bed and all of the opposing cheek were buried. The exposed cheek was constructed from a single piece of timber with four steps. The right trunnion sits inside a deep trunnion recess, with the remains of a heavily concreted iron cap square

[3] The original recording of the carriages shown on the plans were made by the Hazardous Project Team and then in 1990 the Archaeological Diving Unit (ADU) visited the site and archaeologist, Alex Hildred was tasked with investigating the northerly gun and carriage. The author is thankful for Alex who kindly provided her dive log from that dive, which recorded her observations and interpretations of the carriage. Iain Grant, the current Licensee of the site has provided underwater images of the second carriage, which has helped identify other diagnostic features. Both sources of information have been essential for the current interpretations.

extending across the top of the trunnion and cheek. The plans also show a circular hole just behind and below the trunnion recess on the side of the cheek. Immediately below the cheek was evidence of a solid timber bed with the fore and rear axles and trucks (Figure 6.8).

The second carriage attached to gun 12 was immediately behind, also orientated on its side with the right cheek and forward right truck and axle exposed (Figures 6.8-9). The carriage was more exposed and in a poorer state of preservation, with parts of the steps missing from the rear of the cheek. The cheek was again made from a single piece of timber, which was attached to a timber bed. The front axle was attached to the bed, but the rear was missing. As with the first carriage there was a circular hole just behind and below the trunnion recess on the side of the cheek. In addition, there was a large concreted ring bolt attached to the side of the bed (Figure 6.9). Observations made in 2018 found a single iron through bolt survived behind the breeching hole of the right cheek and was still attached at the other end to the left cheek. The bed was completely lost, as was much of the right cheek, to degradation.

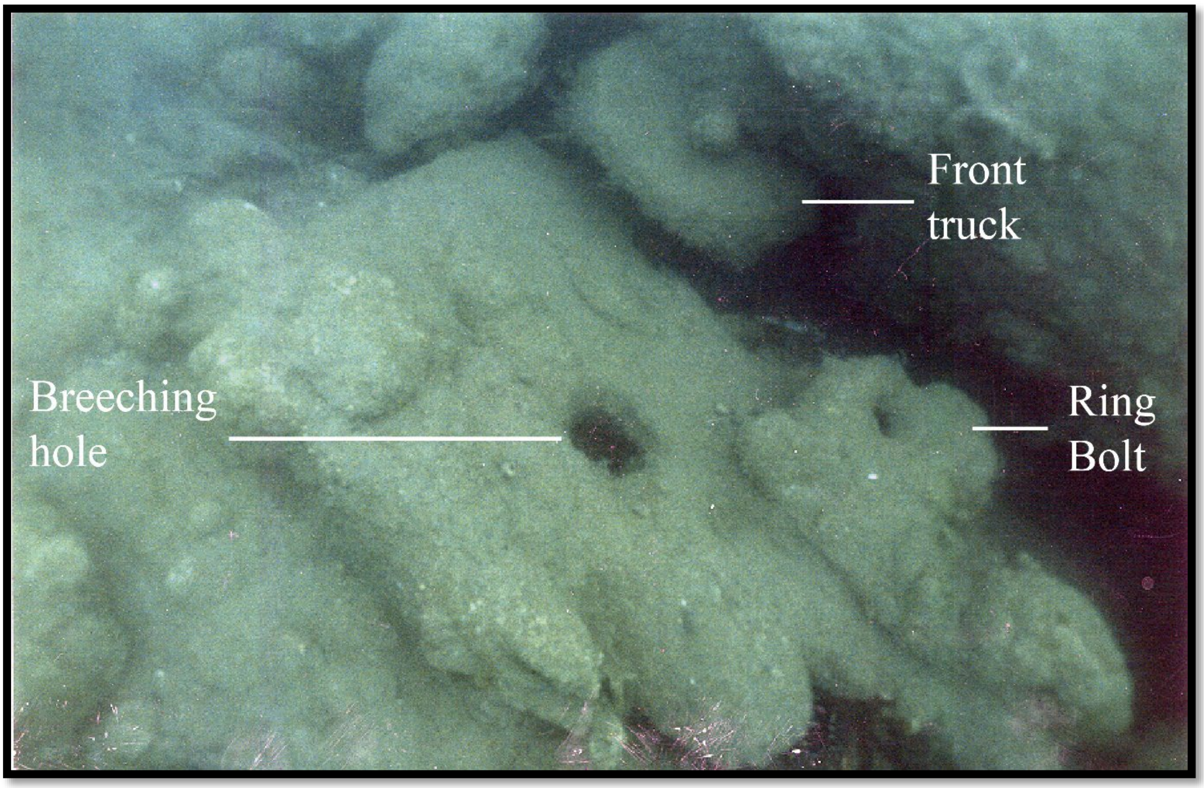

Figure 6.9: A photo of the second carriage showing the breeching hole and concreted ringbolt.

At first glance these carriages would appear to be just like any other truck carriage issued to ships of the Royal Navy. However, some key characteristics set them apart: first, the circular hole observed on both carriages behind and below the trunnion recesses (Figures 6.8-9). These holes were quite deliberate and were made to allow the breeching rope to pass through the carriage. This method of breeching was common with continental navies, including the French. A typical French example was recovered from the wreck of *La Belle,* a small armed French colonial ship lost in Matagorda Bay, Texas, in 1686 (Figure 6.13) (Bruseth et al 2017). Despite being for a smaller gun it has all the characteristics of the *Hazardous'* carriages but without the ringbolts attached to the side of the bed. The *La Belle* carriage also has a timber transom between the cheeks at the front of the bed (Bruseth et al 2017, pp. 373–378). Should sediment levels reduce further on the *Hazardous* then a transom at the front end of the northerly carriage may be revealed.

The origins of these carriages can be easily explained as we are already aware from the historical record that the *Hazardous* was re-issued with 49 of the guns that the ship was captured with (TNA ADM106/594/45). The characteristics of the carriages surviving on the site reveal that the carriages were kept too. This would make sense because the height of the ports above the deck on the *Hazardous* may have been different to heights on British warships and therefore significant alterations would have had to have been made to English carriages to enable the guns to sit at the correct height. The archaeological evidence does show, however, that at least one alteration was made to the carriages and that was the installation of ringbolts on the side of the carriage to suit the British method of breeching the guns (Figure 6.9). The ringbolts allowed the breeching to be guided along the sides of the carriage and back around the cascabel of the gun.

Further evidence of the characteristics of the *Hazardous* carriages derives from three axles, two, **HZA012-14** and **HZA013-14**, found stowed in the hold (Figure 6.10-11) and a third, **HZA003-07**, found outside the structure of the main site (Figures 6.12). Their location and stowage will be discussed in section 6.1.6.3 but relevant to this section is their design and construction. We have seen from English-style carriages recovered from the Duart Point wreck (Martin 2017, p. 152), the *London* (Pascoe 2017a, p. 36), and the carriage at Windsor Castle (Smith 2001, pp. 26–28), that the front axle was secured to the bed by two iron bolts that passed up from the bottom and through the bed on the inside of the cheeks. The location of the holes are different with the *Hazardous* carriages. With the case of the *Hazardous* axles there are bolt holes where the cheeks would line up on top of the bed (Figures 6.10 - 12). On the underside of the axles it is possible to see the impressions left by the bolt heads and washers and on **HZA0012-14** and **HZA0013-14** it looks like these areas were crudely chopped to release the axles from the bed. Evidence from the *La Belle* carriage shows that the iron fastenings were driven up from the bottom of the axle and into the bed, passing to the underside of the cheeks (Bruseth et al 2017, p. 376).

There was one square fixing hole towards the centre points of each axle. The evidence from the *La Belle* carriage shows that a bolt passed up from the bottom centre of the axle and into the transom at the front of the carriage between the cheeks (Figure 6.13) (Bruseth et al 2017, p. 377). These square fixing holes roughly centred along the axle suggest a fixing for a transom timber, which was a feature of a French carriage.

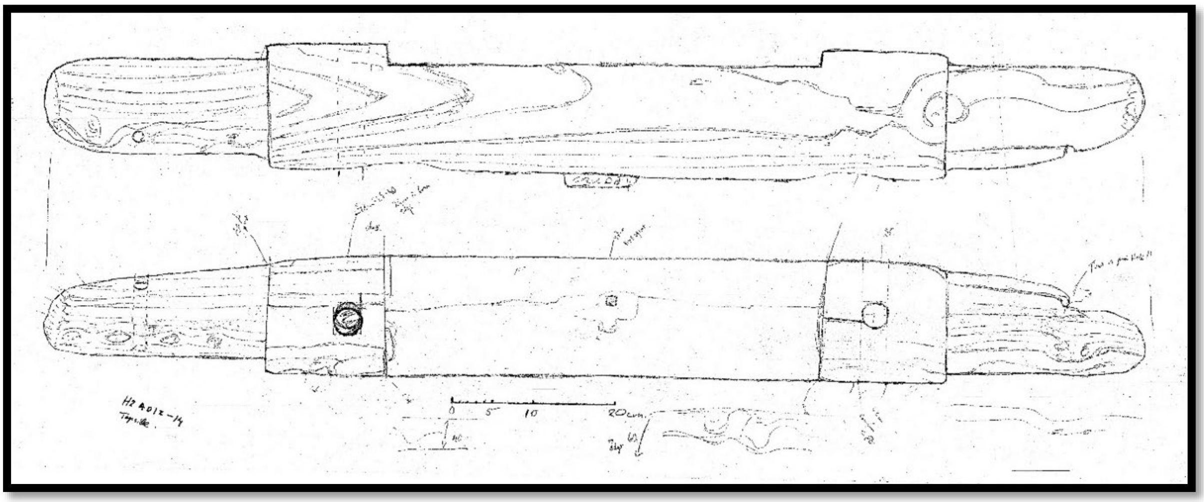

Figure 6.10: Drawing of axle HZA012-14 (Drawing by D. McElvogue, courtesy of HPG)

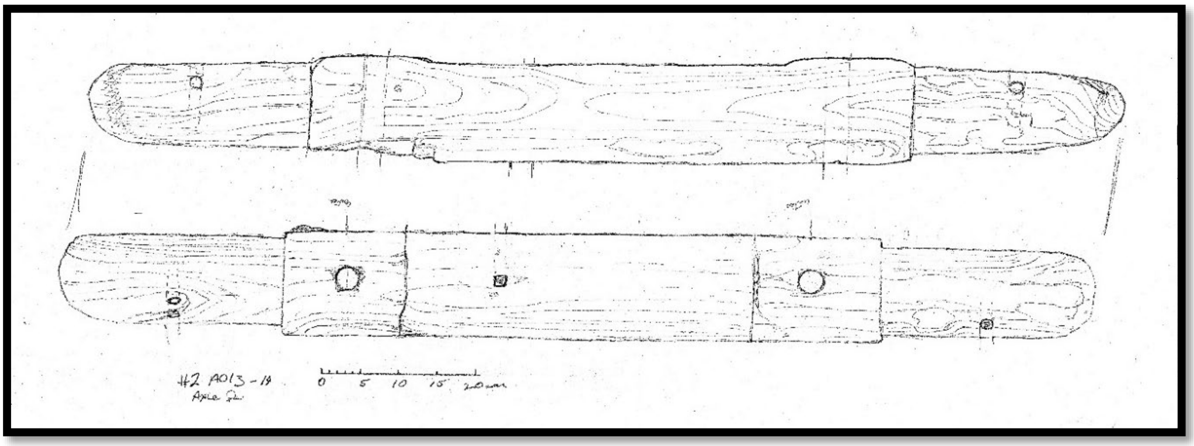

Figure 6.11: Drawing of axle HZA013-14 (Drawing by D. McElvogue, courtesy of HPG).

Figure 6.12: Axle HZA003-07. Top photo is the upper face and bottom photo is the underside.

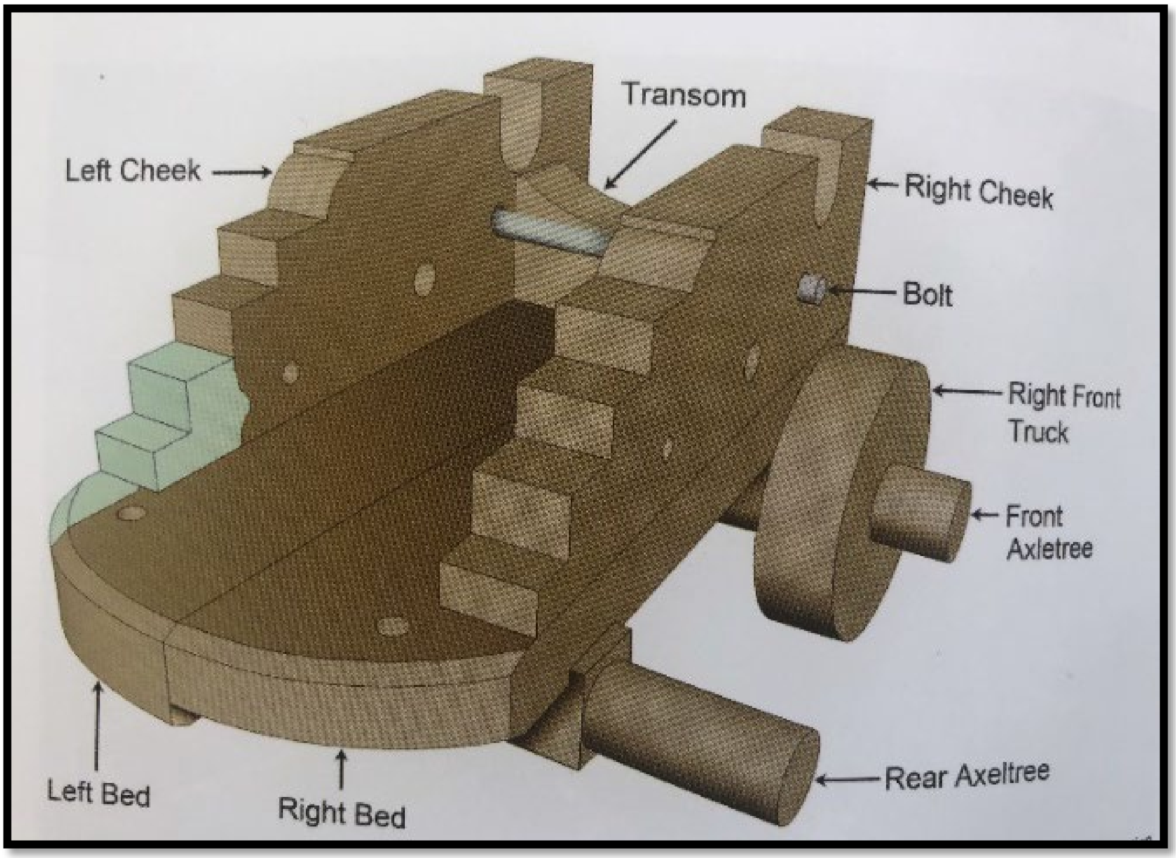

Figure 6.13: A reconstruction drawing of the la Belle carriage (Bruseth et al 2017, p. 374).

There are two other noticeable features that are not present on English examples. First, all three axles have a recess cut into the top surface of the axle (Figures 6.10 - 12). These recesses would fit into recesses cut into the bed of the carriage and an example of such can be seen cut into the lower side of the bed of the *La Belle* carriage (Figure 6.13) (Bruseth et al

2017, pp. 374–375). Recesses on both the bed and axles would act as a joint, known as a stop scarf joint. This type of joint would give greater strength to the carriage and take pressure off the fixings. The second feature is present on axle **HZA012-14** only (Figure 6.10). The arms of the axle do not extend in a straight line, instead they curve backwards by 8º. This was a similar feature to the rear axle of the *La Belle's* carriage and was interpreted as functioning to brake the carriage on recoil as the trucks would be angled towards each other (Bruseth et al 2017, pp. 377–378).

Axles **HZA012-14** and **013- 14** were sampled for species identification at the MRT and found to both be made from elm. According to Povey axles should be constructed from ash or oak but generally ash (Povey 1702, p. 14) and ash was identified as the wood species for the axles of the *Stirling Castle* carriage which would appear to support Povey's description (Tran et al 2011, p. 2). The findings of elm for the *Hazardous* could therefore be another indicator that the carriages were not English.

6.3.2 *Securing the guns on Hazardous*

The position of the guns on the surviving gundeck structure (Figures 6.2 and 6.8) suggest the crew used at least two different methods for securing the guns when in transit and prepared for bad weather. With the guns that have their muzzles pointing west through the side of the hull these were likely to have been secured with the muzzles lashed above the port. This would have meant the guns were fully retracted to enable the closing of the ports and thus the stool bed and coins removed to elevate the muzzle, which would be lashed to eye bolts above the port (Figure 6.14).

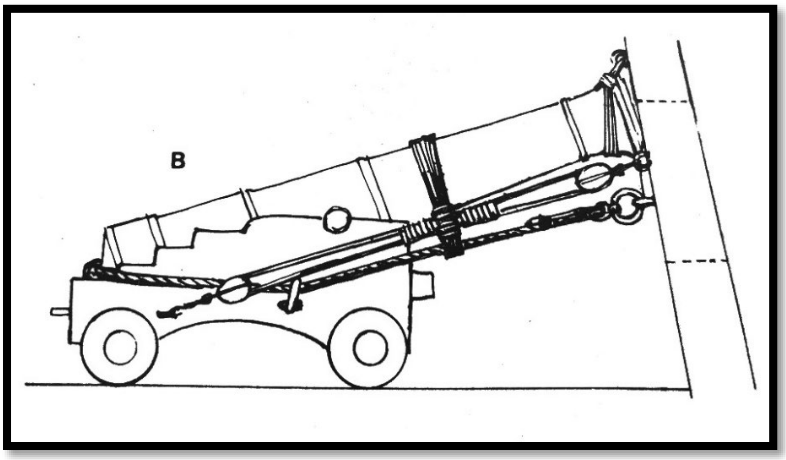

Figure 6.14: Illustration show gun housed with muzzle facing and secured above the port (Harland 1984, p. 210).

The two forward-most guns on the port side are lying against the side of the hull with the muzzles pointing forward. These guns were recorded with their carriages, which show that the guns sit horizontally in the carriage and were not elevated when secured to the side of the hull. If the guns were not elevated to close the ports, the guns would have to have been turned to face up or down the deck and then lashed (Figure 6.15). The orientation on the gun in relation to the gunport, and the level of the gun in the carriage, would suggest it was deliberately turned to be secured alongside the hull. The reason for securing the guns alongside was a space saving measure and there was probably less space at the forward end of the gundeck because the hull narrows towards the bow.

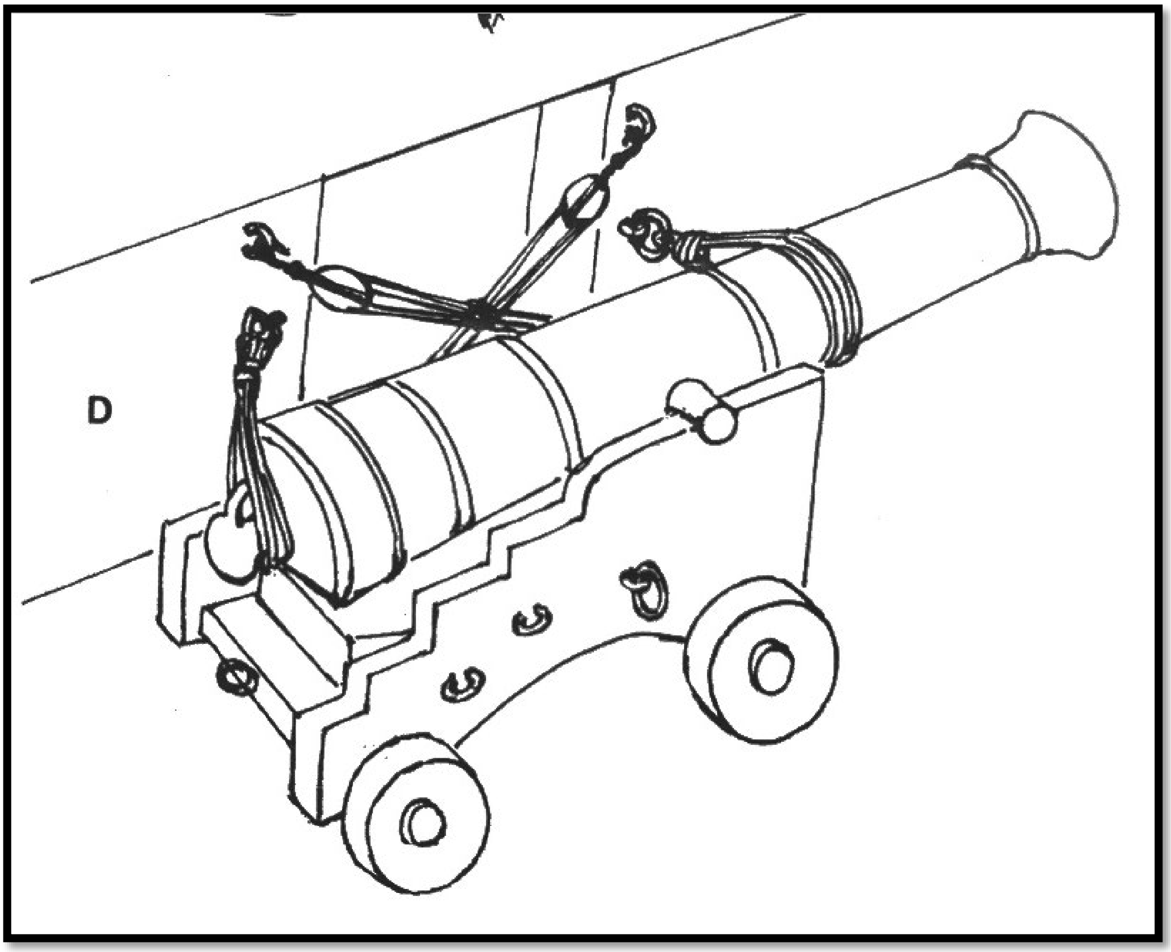

Figure 6.15: An illustration showing the gun lashed alongside (Harland 1984, p. 210).

The *Stirling Castle* gun and carriage – evidence of mounting and securing the guns

A demi-cannon with carriage and some of its associated gun tackle was recovered in September 2000. It was first seen alongside two other guns on the main gundeck at the port stern quarter, adjacent to its gunport but within a relatively short period of time the wreck began to deteriorate (Figure 6.16). Due to the weight of sand within the ship the side of the hull bulged and eventually broke away and the deck collapsed, the gun fell out onto the seabed below and it was therefore necessary to recover it before it deteriorated any further (McElvogue 2008, p. 37).

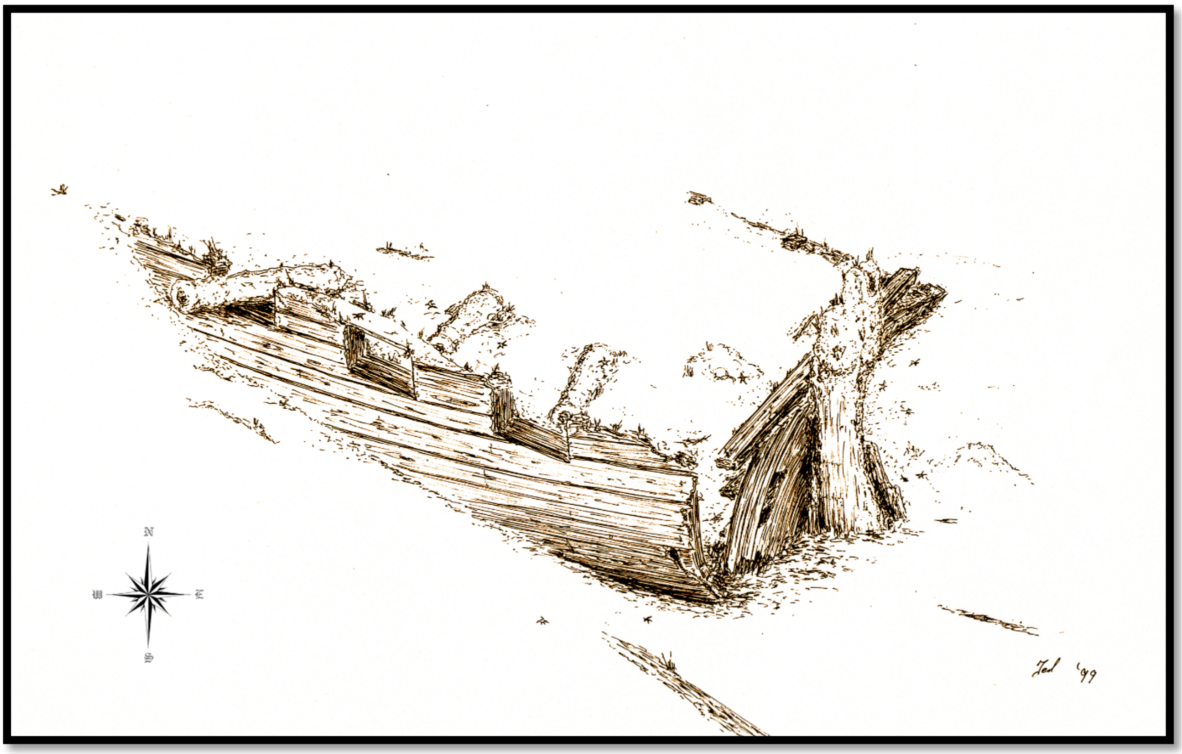

Figure 6.16: A divers sketch showing the exposed guns on the port quarter before the collapse of the hull structure (Drawing by Ted Westhead and courtesy of the Seadive Organisation).

The carriage is a typical truck carriage of the period, but the gun is a more refined Prince Rupert Patent, nealed and turned, demi-cannon (McElvogue 2008). This patent involved a different method of casting to increase quality and performance over the standard rough cast guns (Barter-Bailey 2000). The carriage's construction is similar to the *London's* carriage but it had an additional iron through bolt (three in total) to the support the cheeks and it is without the additional timbers such as the extension piece and planks on the inside of the cheeks (McElvogue 2008, p. 42). Therefore, this carriage was designed for the demi-cannon of 9 ½ feet that it was recovered with. The more interesting features regarding this section were the survival of the gun's breeching rope on the side of the carriage and around the breech end of the gun, and also the muzzle lashings. These identify how the gun was secured and provide evidence of extra security in response to the terrible conditions of the storm (Figures 6.17-19).

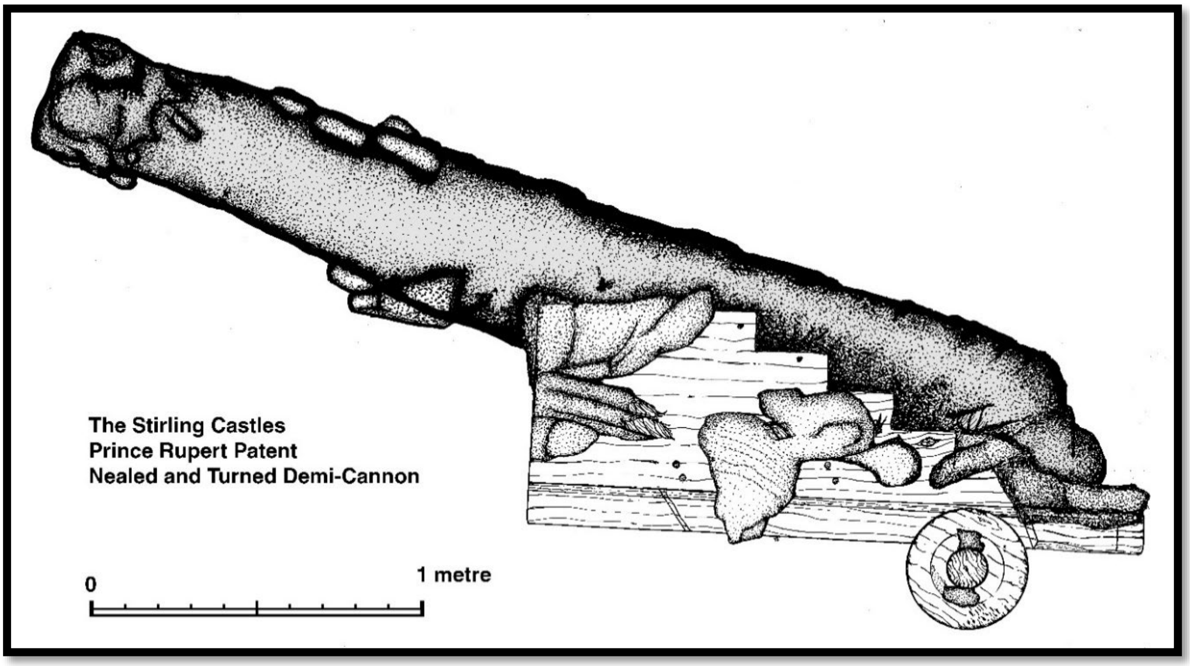

Figure 6.17: Drawing of the gun and carriage before de-concretion. Notice the partially concreted breeching rope at the front and rear of the cheek (drawing by D. McElvogue).

The recovery of the assemblage identified that the gun was positioned in the carriage with the breech end against the rear of the bed and the muzzle fully elevated (Figure 6.17). The de-concreting of the gun revealed hawser laid rope wrapped three times around the muzzle (Figure 6.18). When initially exposed on the site the muzzle was facing the gunport (Figure 6.16). The orientation and elevation of the gun demonstrates that the muzzle was lashed to the side of the hull above the port. The de-concreting of the breech end of the gun and the sides of the carriage revealed two breeching ropes running side by side from the front of the carriage along the side and then around the back of the breech (Figures 6.17 and 6.19). During normal operations, one breeching rope would be necessary, but in this case two separate breeching ropes appear to have been used. The additional breeching rope would seem to be an extra measure of security due to the severity of the storm.

Elements of the gun tackle next to the carriage were also observed in-situ. This included a tangled mess of the rope and single blocks but no double blocks. It is unlikely a gun of this size would not have been equipped with double blocks, so it is likely that the double blocks were not visible when the assemblage became exposed and were lost when the side of the hull fell away.

Figure 6.18: Muzzle lashings (Photo by D. McElvogue).

Figure 6.19: Breeching rope around the cascabel (Photo by D. McElvogue).

6.3.3 *Dressing the guns when not in use*

Aprons of lead
According to the 1677-78 inventory a fourth-rate of 54 guns was issued with 56 aprons of lead (TNA WO55/1650). This meant there were two issued as spares. They functioned in the same way as explained in section 5.1.4.3. A total of nine have been recovered from the *Hazardous*, seven from the main site and one each from the 2014 and 2019 gun sites (Figure 6.20). They are rectangular sheets of lead ranging from 260 by 240mm and 2-3mm thick (Table 6.1). They all have one pair of lanyard holes for securing to the gun. Several of them show the shallow impressions of the guns reinforcing rings. They are generally flat except for one, which is moulded at one end, possibly to fit over the base ring of the gun. Although the others are flat, they do have a faint crease mark at the rear suggesting they were moulded. The dynamics of the site is such that large areas of sand periodically move across the site, the weight of which could easily flatten a thin sheet of lead. If the width dimension is viewed as the critical dimension, then the differences between the smallest and the largest aprons is only 20mm (Table 6.1). From this I would suggest these aprons could fit comfortably on any size of gun issued to the *Hazardous*.

Figure 6.20: Lead aprons recovered from the main site (Photo by author).

Apron artefact number	Length (mm)	Width (mm)	Gun type
Apron 1	260	240	6,12 and 18-pounders
Apron 2	250	260	6,12 and 18-pounders
Apron 3	260	240	6,12 and 18-pounders
Apron 4	255	255	6,12 and 18-pounders
Apron 6	260	250	6,12 and 18-pounders
Apron 7	240	255	6,12 and 18-pounders
Apron HZA007-19	255	240	6,12 and 18-pounders
Apron HZA012-19	255	255	6,12 and 18-pounders

Table 6.1: List of aprons recovered from the *Hazardous*. Orientation: The length is the measurement of the apron when placed longitudinally along the length of gun, the width is the measurement of the apron across the gun.

6.3.4 *Loading the guns*

The evidence for loading the guns on board *Hazardous* comes from spare gun equipment. The first dive of the 2017 season revealed the winter storms had scoured the top surface of sediments within the wreck. This had exposed an area of barrels to a greater extent but also uncovered several fresh finds. Included in the newly exposed finds were gun and rigging equipment that were found scattered among barrels and loose iron shot located between the gundeck beams to the west and shot mound to the east (Figures 6.21-23). Also littered in and around the barrels were large amounts of butchered animal bone, suggesting these barrels contained the crew's meat provisions. The barrels were tightly packed and found lying on their sides and others in the upright position. The location and density of the barrels along with the quantity of bone would indicate this is the ship's store of provisions in an area of the hold, forward of the main mast. This area of the ship would not be the place where spare gun or rigging equipment would have been stored, so these finds have moved during the wrecking process. According to the layout of a fourth rate ship they have moved only a short distance from the gunner's and boatswain stores located on the forward areas of the orlop (Winfield 2005, p. 71).

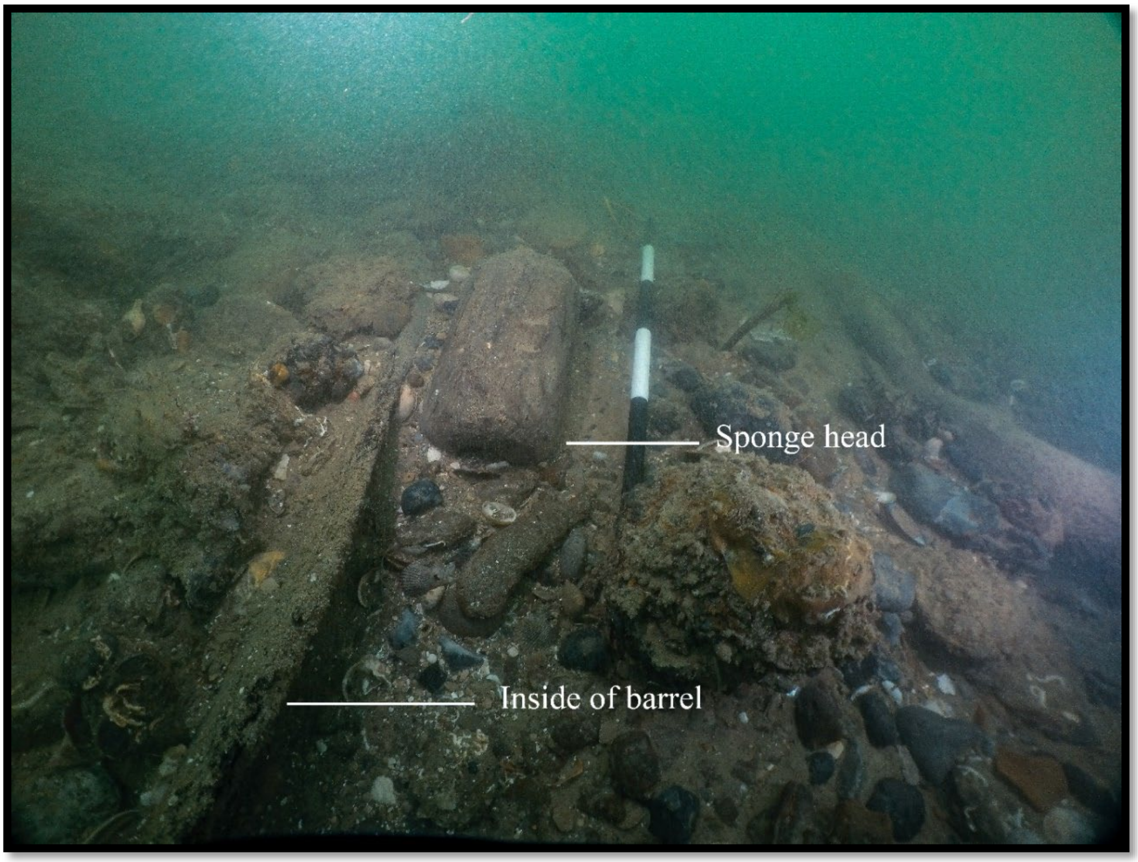

Figure 6.21: Sponge head found alongside the remains of a partial barrel lying on its side in the area of the hold (Photo by author).

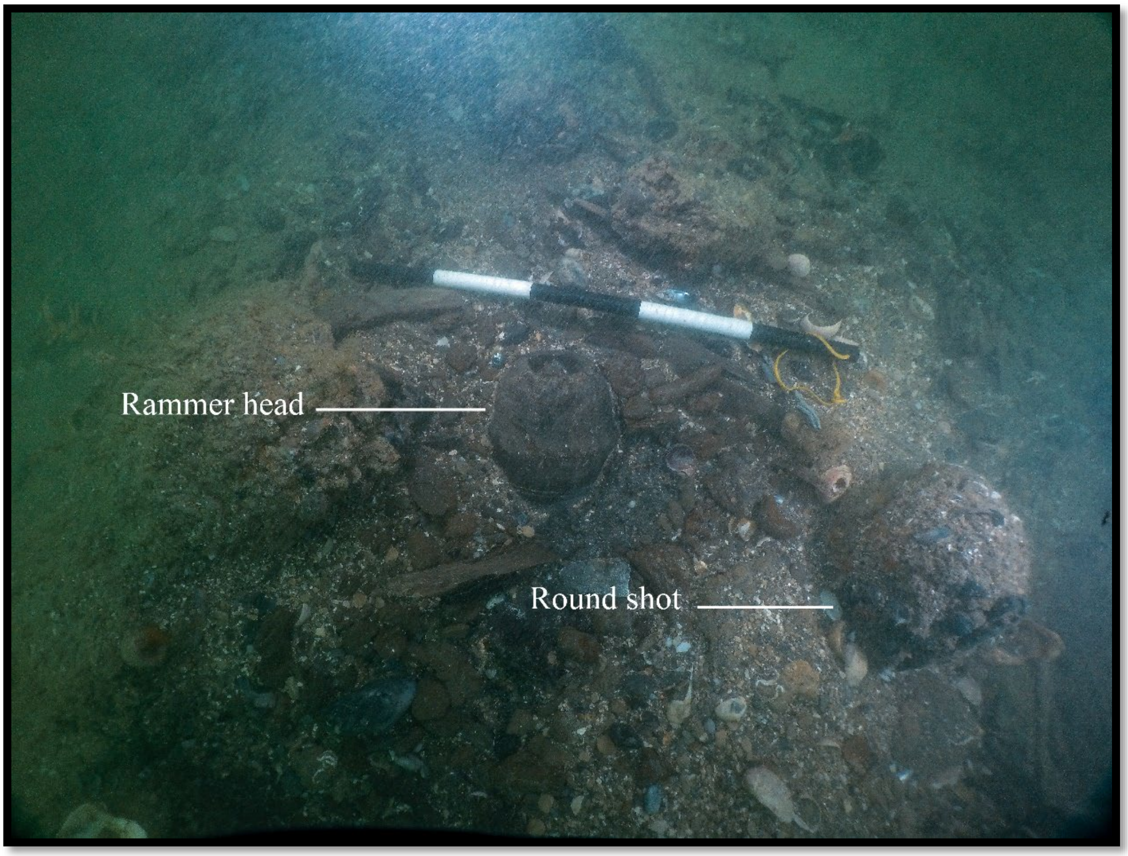

Figure 6.22: Rammer head found in the area of the hold (Photo by author).

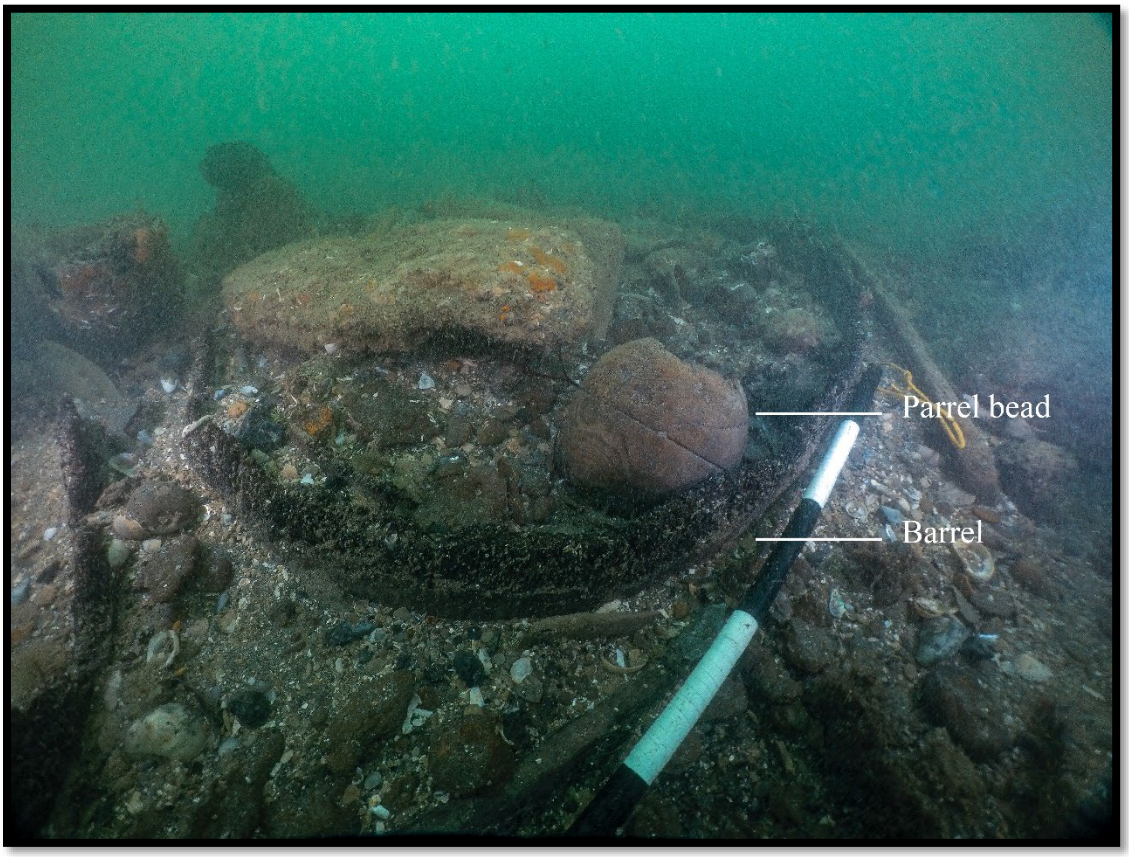

Figure 6.23: Parrel bead found inside an upright barrel in the area of the hold (Photo by author).

Rammer head

According to the gunner's stores lists from the period 1677 and 1716 a fourth rate would carry between 25 and 30 spare pairs of rammer and sponge heads (TNAWO55/1650 and WO55/1739). The variation in numbers corresponded with the number of guns the ship carried, which could range between 50 and 60 depending on the overall size, number of gunports (Winfield 2005) and whether the ship was on duty during war at home or war abroad and in peace abroad and at home (Endsor 2009, p. 148). The current known historical record shows *Hazardous* was issued with 54 guns (TNA ADM106/586/285), so it was most likely issued with more than 25 and less than 30.

A single rammer head **HZA002-17** has so far been found and recovered from the site (Figures 6.22 and 6.24). Analysis of the rammer head revealed it was of English design, in a good state of preservation with no evidence of wear on the edges of the ramming face and there were no fastening holes or remains of the rope or stave. This indicates that this was a spare as opposed to a rammer that was in use. It was turned from a single piece of timber into a conical cylinder; the design had not changed from the examples found on the *London* described in section 5.3.4. The critical dimension is the diameter of the ramming face, which indicates the size of the gun it was intended for. This is 125mm (4.9 inches), which is suitable for the 18-pounder guns. Species analysis by the MRT has identified that the rammer was constructed from ash. This differs from the rammers from the *London* (section 5.3.4) which were made from willow/poplar or alder but matches many of the rammers from the *Mary Rose,* which were made from a mix of ash, poplar and elm (Hildred 2011, pp. 456–57)

Figure 6.24: From left to centre rammer **HZA002-17** and sponge **HZA003-17**.

Sponge head

A single sponge head **HZ A003-17** was recovered near the rammer head **HZA002-17** among the area of the barrels (Figures 6.21 and 6.24). It was also in a good state of preservation and there were no signs of wear or any fastening holes for either the rope of stave handle or for the attachment of the sheepskin sponge. This implies that this was a spare sponge head and not in use at the time of loss. The head has been turned from a single piece of wood in the style similar to that found on the *London* described in section 5.3.4, but the major difference is that this example is not a cone shape. It is marginally narrower at the ramming end (110mm or 4.3 inches) than at the shoulder (115mm or 4.5 inches). Thus, it is designed to fit a home-bore as opposed to a tapered-bore. With the additional thickness of the sheepskin this could only be suitable for the 18-pounder guns. Species analysis by the MRT has identified that it is constructed from ash, which differs from the *London* (section 5.3.4) which was made of alder. The fact that ash has been used to make both the rammer and sponge heads could suggest there was some attempt at standardising the types of timber species used in the manufacture of these pieces of equipment.

Evidence from the *Stirling Castle* - Contents of gun barrel from the *Stirling Castle's* demi-cannon

During the de-concreting of the gun, the inside of the barrel was excavated. It revealed that the gun was loaded, as one would expect, but it is the order and composition of the various components of the load that is of interest with regard to the loading practice. The gun was loaded with a single round iron shot of 5.9 inches, a snug fit for a 6 inch bore; two wads in front of the powder charge and one wad in front of the shot (McElvogue 2008, p. 41). The charge itself was reduced to a black slurry with no evidence of the cartridge, which suggests it was made of paper. The construction of the wads appears scrappy, made from unpicked strands of rope (Figure 6.25). This is in contrast to the individually picked yarns made into neat, tightly wrapped wads like that from the *London* described in section 5.3.4. Found with the two wads in front of the charge was a piece of cord tied in a loop by a reef knot and an over hand knot (Figure 6.25) (McElvogue 2008, p. 41). This may have been used to stop the roughly-made wad, or wads, falling apart. The poor construction of the wads may also explain why two were needed. The purpose of the first wad was to create a seal to stop gases escaping around the shot and reducing the power. An ill-fitting and poorly made wad would not succeed in doing this and therefore the loader may have felt it necessary to use two. The differences may seem minor, but I believe it reveals where they were made and under what circumstances, which will be discussed in section 6.4.4.

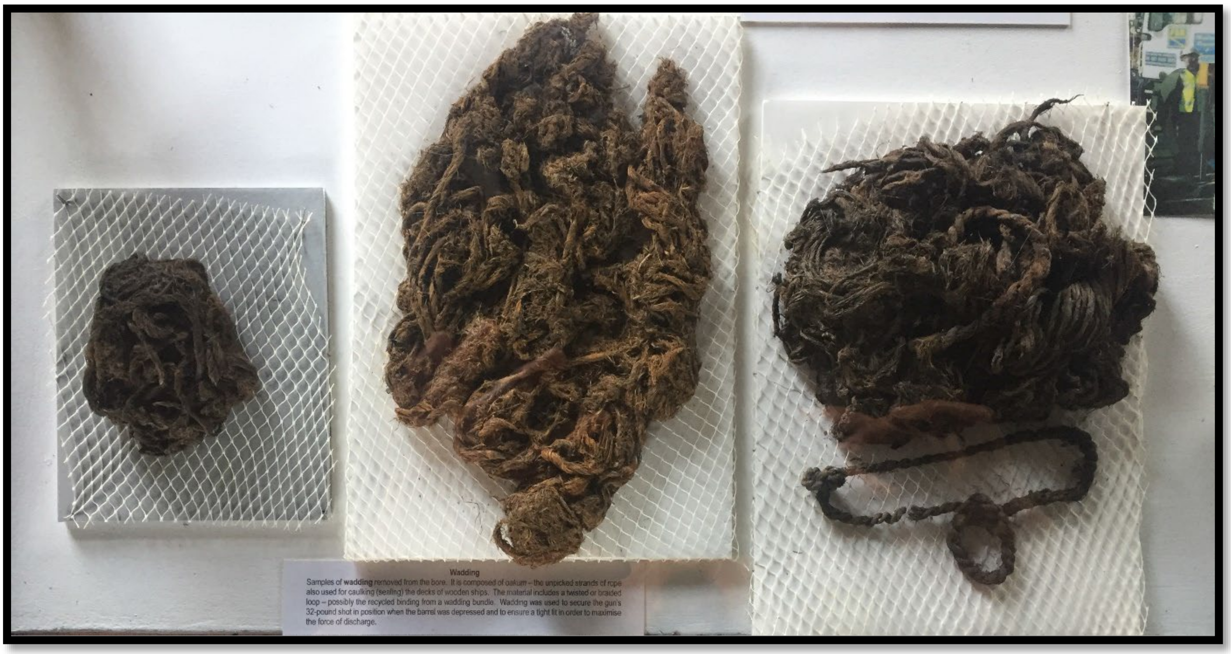

Figure 6.25: Wads on the right and centre made from unpicked strands of hawser laid rope (Photo by author).

6.4 EVIDENCE FOR SUPPLY AND ORGANISATION OF THE GUNNERY SYSTEM

6.4.1 *Shot*

Supply

During the late 17th and early 18th century there were many types of projectiles that were fired from the great guns, each designed to damage different parts of the ship and also mame and kill the opposing crew. English gunnery, like most, focused heavily on targeting the hull and the most effective projectile for this was the round shot, which was issued to all rates of ships in much greater numbers than any other type of shot. Ordnance inventories of this period reveal the variety of different types of shot, all of which could have potentially been issued to the *Hazardous* and the other ships mentioned in this chapter (Table 6.2 extract from TNA WO55/1650). Contemporary descriptions of their form and use were provided by the work of Povey in his Sea Gunners Companion of 1702, which fits neatly into this time frame.

Type of shot	Culverin/ 18-pounder	Demi-culverin/ 12-pounder	Saker/ 6-pounder
Round shot	1320	1320	600
Double head hammered	200	200	90
Double head cast	0	0	0
Tin cases filled with musket shot	0	200	200
Bars of iron	300 between all guns		
Bace and bur	3 cwt		

Table 6.2: Supply and type of shot for a 4th-rate with 54 guns according to the 1677 establishment. (TNA WO55/13). All of these shot types also feature in Povey's inventory of 1702.

Povey lists several other types of shot as follows: double head hammered is a form of bar shot, which is a single piece of hammered (forged/wrought) iron, with each end flared to the size of an equivalent round shot. The forged iron gave this shot strength and was therefore capable of causing great damage to masts, knees, beams, and iron bolts. Double head cast shot is two round cast shots, connected by a cast iron bar. As the shot was cast it was not as strong as the hammered iron and was therefore used to take down rigging. Bars of iron were around 18-20 inches in length, with rope yarns attached at each end. These were tied together in groups of two, three or more depending on the size of the gun and were used against the rigging and personnel on the decks. Bace and bur, which according to Povey were pieces of iron cut from the neck of iron round shot when taken out of the mould (Povey 1702, p. 15). These pieces of iron would need to have been put into a container, which was then loaded into and fired from the gun. This was an anti-personnel projectile used for clearing the decks. The archaeological evidence for a container was found on the Duart Point wreck in the form of two conjoining segments of a four-part wooden cylinder. The container had been turned from a round billet of wood, probably from a straight branch. It had been quartered and the centres hollowed out to contain the shot. The wooden container would break up after firing out, spreading out once clear of the barrel. There was no evidence of the shot but lots of lead shot was found on site including examples with gouged surfaces (Martin 2017, p. 161). The inventories also list tin cases filled with musket shot, which Povey adds were fixed at either end with wood the same diameter as the size of round shot intended for the gun. Like the bace and bur shot they were an anti-personnel projectile and were generally made for guns from the upper decks (Povey 1702, p. 15).

Regarding the supply of shot to the *Hazardous* one must take into consideration that she was equipped with French guns, with the possible exception of the replacement 18-pounder and additional 6-pounders. This would have made the supply of shot potentially less straightforward as there were slight differences in the sizes of the bore and shot between French and English guns (Table 6.3). The French 18 and 12-pounder had a larger bore than the English equivalents, so it would have been possible to fire English shot from the French guns. To keep the supply of shot simple for these guns it would have sensible that the replacement for the one defective 18-pounder was either another captured French gun or an English culverin, largest. This would have meant both English and French shot could be fired from the guns. The bore of a French 6-pounder was marginally smaller at 93mm (3.66 inches) than the bore of an English 6-pounder, which was 98mm (3.7 inches). English 6-pounder shot was 89mm (3.49 inches). In theory it should have been possible to fire English and French shot from both English and French guns and when studying shot recovered from the wreck there is potential to find both.

English gun types	**Bore mm/inch**	**Shot mm/inch**	**French gun type**	**Bore mm/inch**
Culverin, largest	137mm/5.4in	132mm/5.2in	18-pounder	139mm/5.47in
Culverin, ordinary	132mm/5.2in	127mm/5in	NA	NA
Culverin, best	127mm/5in	117mm/4.6in	NA	NA
12-pounder	117mm/4.61in	4.4in	12-pounder	121mm/4.76in
6-pounder	94mm/3.7in	3.49in	6-pounder	93mm/3.66in

Table 6.3: Table showing the differences in bore sizes between equivalent English and French guns. The sizes of English guns, which also include the size of shot comes from Captain Francis Povey's Sea-gunners companion from 1702 and the French sizes comes from J. Boudriot research on French sea service iron guns (Boudriot 1996, p. 87).

Organisation of shot on board

The shot collectively had considerable weight, so it had to be distributed in a way that maintained the stability of the ship but at the same time allowed easy access when needed. For these reasons, the bulk of the shot was stored low down, around the centre-line of the ship, in lockers, generally fore and aft of the main mast and pump wells (Lavery 1984, p. 159, 1987, p. 150). Shot for immediate use was found on the gundecks and by the turn of the century it was stored on racks along the sides between the gunports (Lavery 1987, p. 150). The surplus stores of the less robust cases of base and bur and tins of case musket shot were probably stored separately, as evidence from the *Vasa* identified kegs filled with lead shot which were found stored in the forward-most section of the hold (Cederland 2006, p. 371, Hocker 2015, p. 63). It was probable that this was the main supply of lead shot to fill wooden or tin canisters.

Evidence from *Hazardous*

There are three main areas of the *Hazardous* wreck and they all contain shot for the ship's great guns, but the type of ammunition and the density differs between each area. The distribution and type of shot will give some indication of where it was stored on board. We must, however, not forget that an unknown quantity of gunner's stores, which could have included shot, was recovered during contemporary salvage operations (TNA ADM106/625/144). Therefore, we are dealing with a partially disturbed site and not a complete assemblage.

The *Hazardous* main site

There is one main concentration of shot, concreted to the lower hull on the east side of the main site (Figures 6.2 and 6.26). Inboard of this shot mound are scatters of loose, heavily concreted shot (Figure 6.26). The shot mound is 5.7m long by 2.25m wide by 1.5m high and on inspection the size of concretions forming it suggest it is made up of predominantly the heavier 18 and 12- pounder round shot. This is not surprising as the inventories show that the volume of shot for the larger guns were over double the amount than for the 6-pound shot (Table 6.2). Also, the lighter 6-pounder shot was most probably stored in a higher compartment of the shot locker and therefore more reachable to contemporary salvors. This observation is strengthened by past shot sampling by the HPG which found mainly 18 and 12-pounder shot, with one exception of 6-pound shot and a conglomerate of 1-pound shot (Figures 6.27-28).

Figure 6.26: Orthophoto mosaic showing shot mound including confirmed double loose headed shot (plus recovered example, **HAZA012-20**) and the area cleared of loose shot for the excavation. The scale in the image is 1m with 20cm increments and the double headed shot are marked by dashed lines (Image produced by author).

Figure 6.27: In order from the left 18, 12 and 6-pounder round shot. The scale is 20cm with 1cm increments (Photo by author).

Figure 6.28: A cluster of grapeshot recovered from the site (Photo by author).

The 1-pound shot are too small for any of the guns to be fired singularly but packed together in a canvas bag they could be fired as a group, known as grape shot. According to Povey they were fired in numbers of 20 or 30 which could pierce a ship's side (Povey 1702, p. 15). However, grape shot does not seem to officially appear in inventories until sometime after 1702. An inventory from 1716 identifies that grape shot was issued in both loose form and bagged up appropriate for all calibre of guns (TNA WO55/1739).

Two examples of double head shot were also found in the past when excavating a recovered concretion. The heads were cast iron hemispheres (Figure 6.29). Only one hemisphere with a small section of the bar has survived. It was coated with several layers of paint and during inspection it wasn't possible to tell whether the remains of the bar was cast or wrought. The current measurements of it should be considered alongside the fact that there has been a degree of expansion since its recovery from the seabed. Its current diameter at the head is 133mm (5.2 inches) and therefore is likely to be appropriate for the 18-pounder guns, if following Povey's description this is an example of the double head cast shot used to target rigging. The inventories show that ships of all rates were no longer issued with double head cast shot from 1677 onwards (TNA WO55/1650). The hemisphere, instead of a solid ball, appears, however, to be French in type, as examples have been recovered from a wreck at Saint Nazaire Harbour in France of French origin (Baron et al 2017, p. 90) and this type is illustrated in a French gunner's companion 'Memoires d'Artillerie' (Surirey de Saint Remy 1697). It is therefore highly possible that the double head cast shot was French.

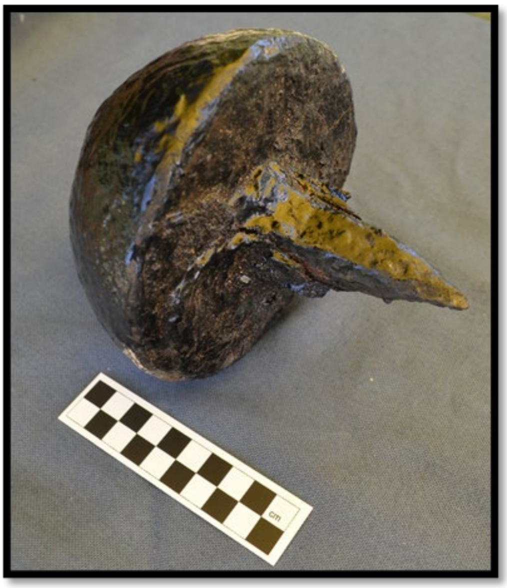

Figure 6.29: Surviving example of one of the cast iron hemispheres from a double headed shot. The scale is 10cm with 1cm increments (Photo by author).

During the current excavations several loose shot were removed from the excavation area and placed outside the south end of the site. One double head shot, **HAZA012-20** was recovered for detailed recording and identification (Figure 6.26 and 30). Following de-concreting it was found to be made of wrought iron. It was 350mm (13.8 inches) long with a maximum diameter at the head of 104mm (4.1 inches) and therefore appropriate for the 12-pounder guns (Figure 6.30 and table 6.2), if following Povey's description this is an example of the double head hammered shot used to target masts and hull structure. The design, construction and form of all the shot will be discussed in more detail in section 6.4.2.

The discovery of double head (hemisphere) cast shot alongside double head hammered shot suggests the *Hazardous* was issued with both French and English types of shot. As mentioned earlier in this section this was possible as the bore sizes of French 18 and 12-pounder guns are slightly larger than the English equivalents and the French 6-pounder bore size were only marginally smaller, therefore it was possible to fire English shot as well as French shot from *Hazardous'* guns. An example of a double head hammered shot was also recovered from the wreck of the third-rate *Stirling Castle*, lost on the Goodwin Sands during the Great Storm of November 1703 (Whitewright 2020, p. 146) (Figure 6.31). This provides further confirmation that double head hammered shot was the preferred bar shot of choice for the English navy.

Figure 6.30: Photo of double headed shot **HAZA012-20** recovered from main site in 2020. The scale is 20cm with 1cm increments (Photo by author).

Figure 6.31: Photo showing double head hammered shot at top of image (Photo courtesy of the Maritime Archaeology Trust (MAT)).

The size and location of the shot mound on the *Hazardous* main site would suggest this was a large proportion of the *Hazardous'* main supply and storage of shot. Its current location would suggest it originated from a locker forward of the main mast, but which shifted a few metres forward since the wrecking event. There is no evidence of the structure of the locker and this was likely destroyed when the shot moved. The lack of another major group of shot aft of these would appear to suggest that there was not a second locker behind the main mast, unless of course the shot from there was salvaged. The evidence to support a single locker comes from the plan of another captured French fourth-rate, the *Superb,* also built by Pierre Coulomb (Winfield and Roberts 2017, p. 138), which shows it was fitted with only one shot locker, forward of the main mast (Figure 6.32).

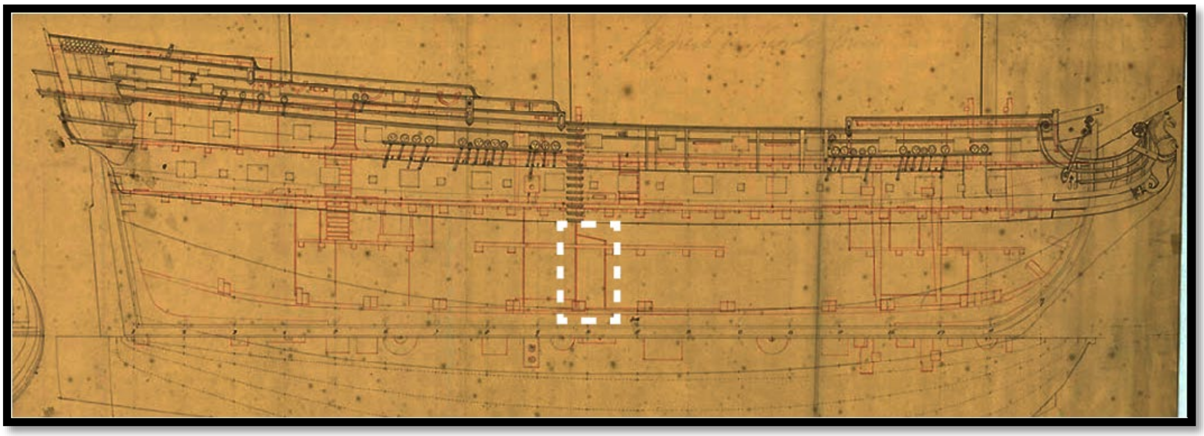

Figure 6.32: A plan of the *Superb* showing a single shot locker forward of the main mast (Image J4012 ©National Maritime Museum, Greenwich, London).

There are other plans of fourth-rates which show lockers forward and behind the main mast and even others with a single locker behind (Winfield 2005). This demonstrates there were several options for fourth-rates, but the archaeological evidence on the *Hazardous* site supports a single locker. The size and type of shot seen at this location shows that the heavier 18 and 12-pounder shot was stored at the bottom and the lighter 6-pounder shot, if originally stored here, would have been at the top. The evidence of double head shot loose on the port side structure immediately west of the main concretion suggests that the double head shot was stored in a compartment of the locker above or to the side of the round shot. As the surviving ships structure confirms that the *Hazardous* healed over onto the port side, the shot would naturally fall to port. For the double head shot to be at its current location it is likely to have been separate from the round shot to fall clear of it.

The *Hazardous* 2014 gun site

Clusters of round and double head shot have been recorded at the site. Some of these clusters can be seen in the 2019 orthophoto mosaic[4]. One main cluster of shot is in the northwest corner of the site (Figure 6.33). At least five heavily concreted double head shot can be seen among the more numerous round shot. There are other clusters outside the boundaries of the current survey, but they have not been surveyed at this time. Two double head shot, **HAZA010-20** and **HAZA011-20**, were recovered in the summer of 2020 and following de-concreting they were found to be of the wrought iron variety, referred to as double head hammered shot in contemporary inventories. All the double head shot is heavily concreted

[4] All the shot on the seabed are heavily concreted, which does disguise the original form of the shot. The round shot are more numerical and generally easier to spot in the images. Anything roughly spherical in shape is a likely round shot. The double head shot is less clear, so their outlines have been marked out with dotted lines.

and appears roughly square in section at the heads and along the bar. This is opposed to cast iron double head shot which are spherical at each end. Although heavily concreted it is fairly easy to distinguish between wrought and cast iron double head shot underwater. The shapes of the double head shot on the 2014 gun site are all consistent with the wrought iron type. The **HAZA010-20** weighed 7.5kg (16lb 7oz) and was 390mm (15.3 inches) long, a maximum of 52mm (2 inches) thick along the bar, with a maximum diameter at the head of 119mm (4.7 inches) and therefore an appropriate size for the 18-pounder guns. **HAZA011-20** weighed 3.7kg (8lb 1oz) and was 354mm (13.9 inches) long, a maximum of 37mm thick along the bar, with a maximum diameter at the head of 90mm (3.5 inches) and therefore appropriate for the 6-pounder guns.

The clusters of round and double head shot dispersed among this group of 12 and 6-pounder guns demonstrates that both types of shot were stored on the gundecks decks for immediate use. The greater number of round shot reiterates that this was the preferred projectile of choice. The recovery of a double head shot for an 18-pounder (**HAZAO10-20**) may seem surprising among the smaller calibre guns but, considering the violence of the wrecking event, it is highly probable that shot from the main gundeck could have broken out as the sides of the hull fractured.

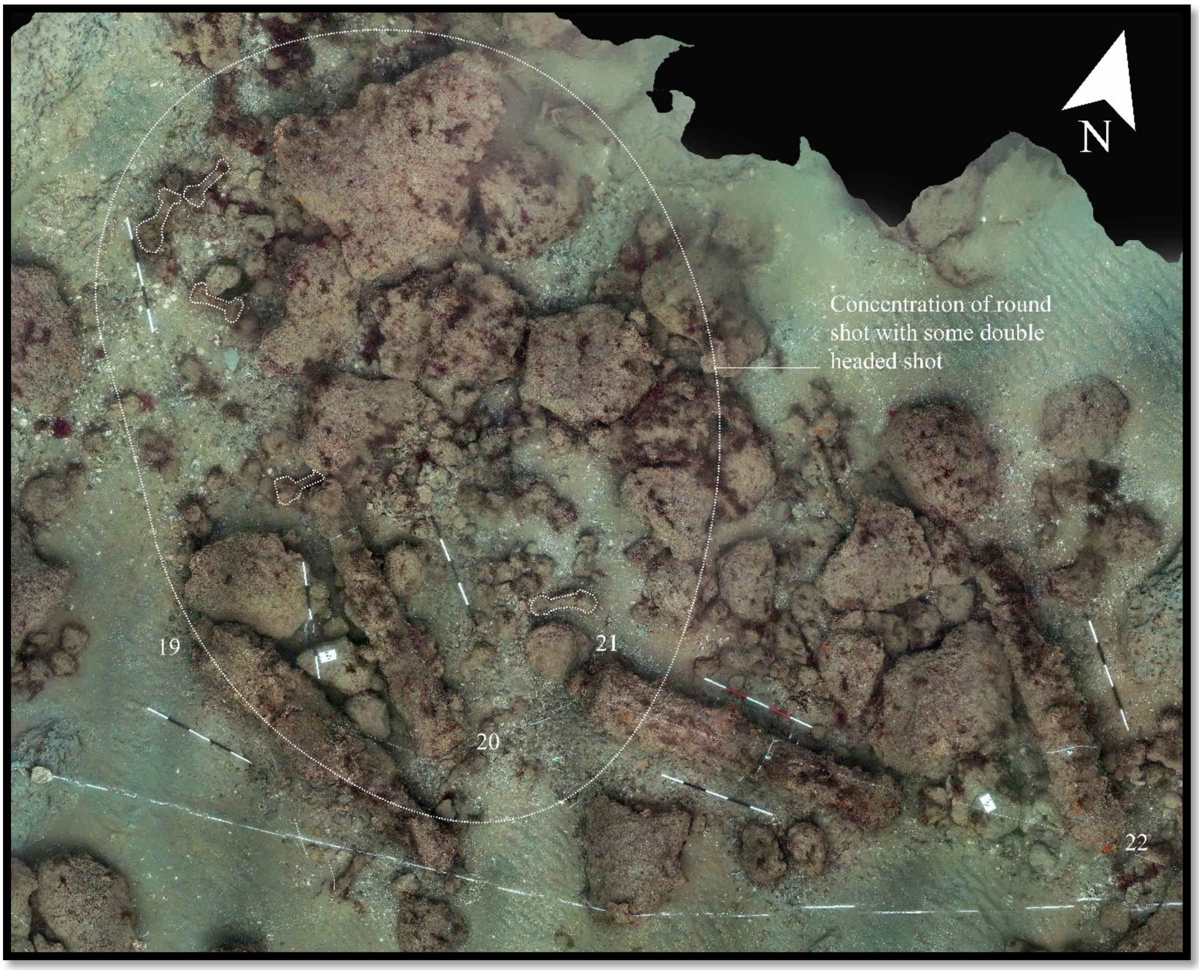

Figure 6.33: An orthophoto mosaic of the NW corner of the 2014 gun site showing the location of double headed (outline traced with dotted lines) and round shot. The scales in the image are all 1m with 20cm increments (Image produced by author).

The *Hazardous* 2019 gun site

Even greater numbers of both round and double head shot were recorded at the 2019 gun site, including in the extended area to the southwest (Figures 6.34 and 6.35). The round shot are still more numerous, as one would expect, but there are significant numbers of double head shot. Four samples of double head shot and one round shot were recovered from the extended area of the 2019 gun site. Two double head shot, **HAZA007-20** and **HAZA008-20,** and round shot, **HAZA009-20,** were de-concreted and **HAZA0032-20** and **HAZA033-20** were kept in their concreted state and CT scanned at the University of Southampton. The results of the CT scan will be discussed in detail in section 6.4.2 regarding the construction and form of the shot.

All the double head shot were of the wrought variety referred to as double head hammered shot in the inventories. **HAZA007-20** weighed 8.6kg (19lb) and was 367mm (14.5 inches) long, with a maximum thickness along the bar of 51mm (2 inches) and a maximum diameter at the head of 120mm (4.7 inches). It is therefore an appropriate size for the 18-pounder guns. **HAZA008-20** weighed 7kg (15lb 7oz) and was 395mm (15.5 inches) long, with a maximum thickness along the bar of 47mm (1.9 inches) and a maximum diameter at the head of 107mm (4.2 inches). It is therefore appropriate for the 12-pounder guns. The round shot **HAZA009-20** is cast iron weighing 6.8kg (15lb 1oz) with a diameter of 127mm (5 inches) and therefore appropriate for the 18-pounder guns.

The discovery of round and double head hammered shot at the 2019 gun site confirms the point made previously made that significant amounts of both these types of shot were stored on the gundecks for immediate use. The lack of double head cast shot on the 2019 and 2014 gun sites suggests this type was not stored on the gundecks for immediate use or, if it was, it was in smaller amounts that have yet to be found on these areas of the site. The evidence so far has only confirmed the presence of double head cast shot on the main site, which therefore appears to have been stored below deck.

Figure 6.34: An orthophoto mosaic of the 2019 gun site showing the locations of round and double headed shot (outlined traced with dotted lines) (Image produced by author).

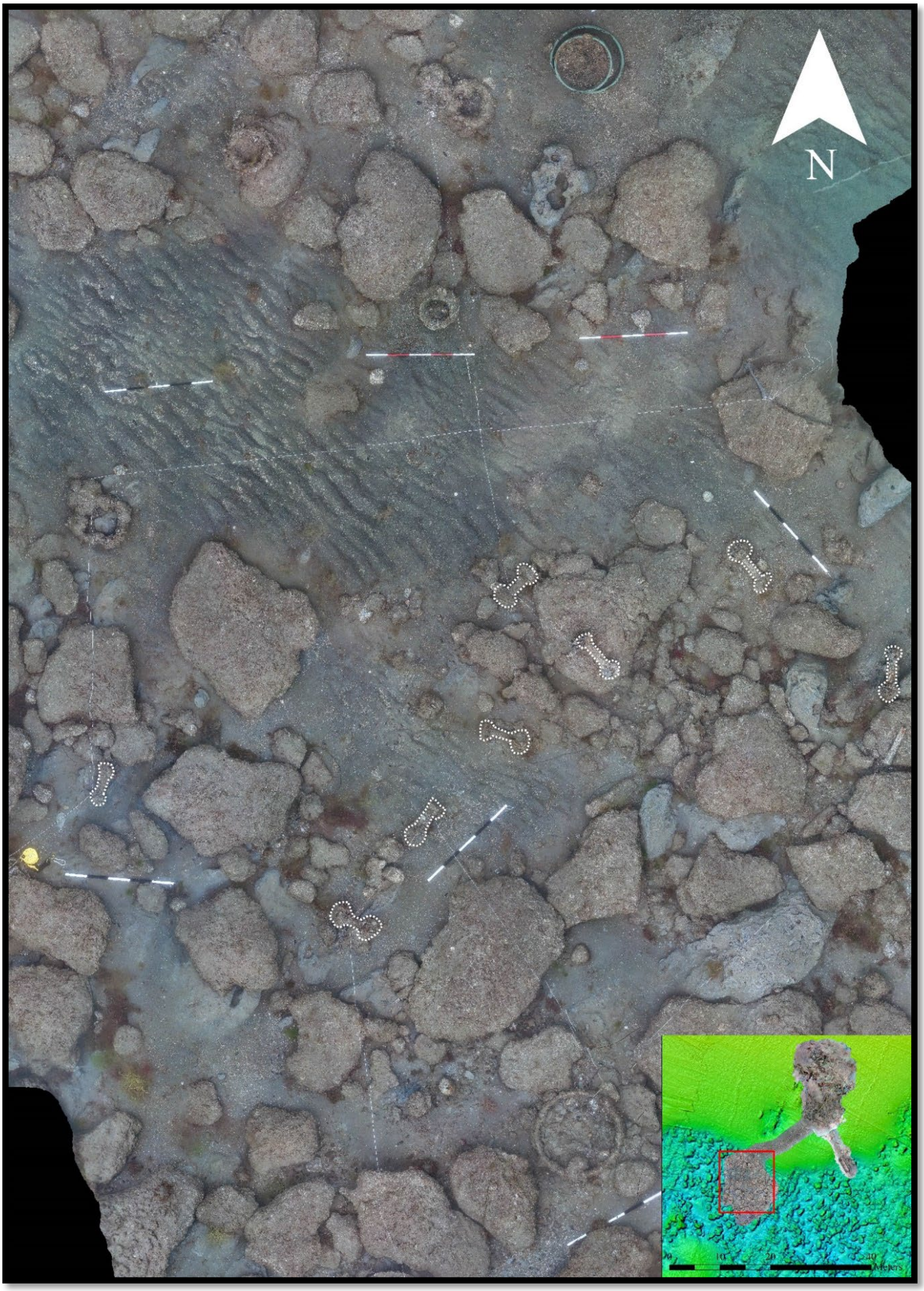

Figure 6.35: An orthophoto mosaic of the extended area of the 2019 gun site showing location of shot. The double headed shot is outlined with dotted lines. All scales in the image are 1m with 20cm increments. The inset shows the extended area in relation to the main part of the 2019 gun site (Images produced by author).

Other evidence from other sites

One type of shot that was issued to all rates of ships in large numbers but does not appear to be reported as such in the archaeological record of shipwrecks, are bars of iron (Table 6.2). Admittedly, bars of iron do not spring to mind as a type of projectile to look out for on a wreck unless the inventories are studied carefully. After centuries underwater, ferrous objects become heavily concreted and bars of iron, if clustered together, generally become unrecognisable or, if isolated, dismissed as corroded iron bolts and therefore left in-situ. This may result in them being recorded on the seabed but their identification being misinterpreted. One such example of this could be from the wreck of the 70-gun *Northumberland*, sister ship to the *Stirling Castle* and lost during the same storm on the Goodwin Sands in November 1703 (Pascoe and Peacock 2015).

The *Northumberland* shot locker (70-gun warship wrecked 1703)

There is a large concretion towards the southeast end of the site, which lies on top of a section of the lower hull structure (Pascoe Archaeology 2017b, 2018a). Due to its size it was originally interpreted as a shot locker (Pascoe and Peacock 2015, p. 134). Inspection of the concretion in 2018, however, found it to be a more complex concreted assemblage of objects, including ceramic, lead and concreted wooden objects (Figure 6.36). There was evidence of round shot, but the main bulk of the concretion appeared to be made up of unidentifiable concretions (Pascoe Archaeology 2018b, pp. 8–9). Subsequent reassessment of the photogrammetry and video records show that many of the concretions were linear in shape and appear in a tangled web all over the feature (Figure 6.36). Some of the linear concretions flare out at the ends and others are fairly regular. These could potentially represent the wrought iron double headed hammered shot and the bars of iron (Figures 6.37-39). A section of one of these linear objects had lost its concretion and the grain of wrought iron was revealed, which are consistent with the form of a bar of wrought iron (Figure 6.37).

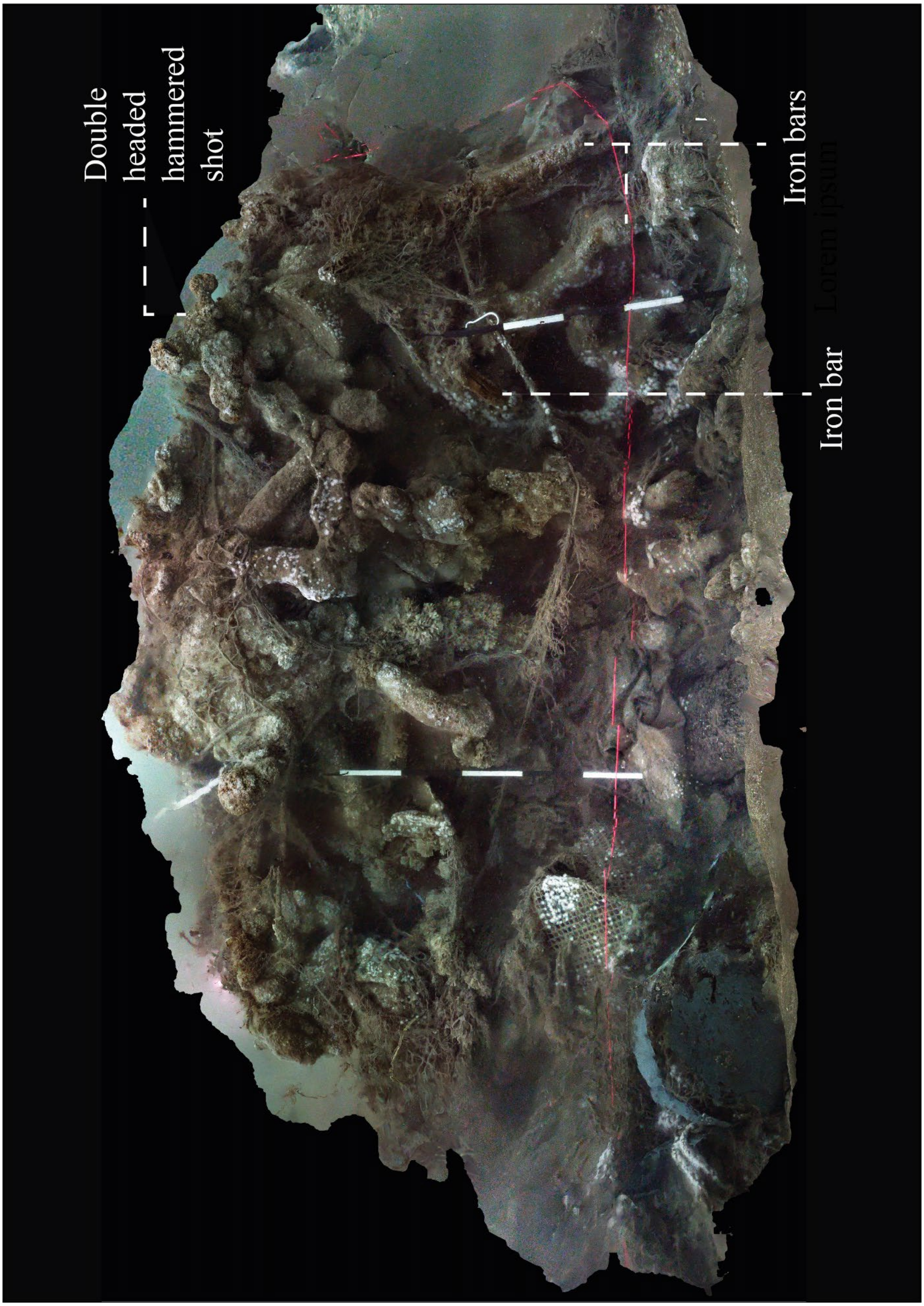

Figure 6.36: An orthophoto mosaic of the south face of concretion mound, consisting of round shot, double headed hammered shot and potentially bars of iron. The round shot are there but obscured by other concretions. The scales in the image are 1m with 20cm increments (Image produced by author).

A 70-gun third-rate ship of the line would have potentially been issued with up to 350 bars of iron (TNA WO55/1650), 18-19 inches in length (Povey 1702, p. 15) and 396 double headed hammered shot (TNA WO55/1650). The bulk of these were most probably stowed low down with a smaller amount stored on the gundecks for immediate use, as has been found on the *Hazardous*. However, during exceptionally bad conditions, such as the night of the Great Storm, it would have been extremely dangerous for the crew to have heavy objects stored on the decks unless they were well secured. This extremely large and complex concretion mound may be the evidence that the shot stored on the decks was moved to the shot lockers in the hold for reasons of safety. So, the original interpretation as an area of shot was probably correct but, rather than simply round shot, it consists of more and all types of shot, including the cruder bars of iron and double headed hammered shot. It is these types, and their quantity, that could be obscuring the bulk of round shot beneath.

Figure 6.37: Photo showing a de-concreted section of bar that is clearly made of wrought iron. The scale showing is two 20cm increments of a 1m scale. (Photo by author).

Figure 6.38: A possible group of double headed hammered shot (Photo by author).

Figure 6.39: A possible concreted bar of iron to the left of a pulley sheave at the foot of the concretion mound. The scales are 1m with 20cm increments (Photo by author).

6.4.2 *Manufacture of shot*

Round shot

Round shot are the most common on site representing all calibres of the great guns: 6, 12 and 18-pounder. Except for one shot, **HAZA009-20**, all were recovered at various times in the past and they were often part of a larger concretion. As a result, these earlier shot do not have an individual artefact number. A small sample from each size were measured and photographed; all are spherical in shape. The 6-pounder shot had a diameter of 87mm (3.4 inches) and weighed 2.3 Kg (5lb 1oz); the 12-pounder shot had a diameter of 112mm (4.4inches) and weighed 5.3kg (11lb 10oz); and the 18-pounder shot (two were measured) had a diameter range of 127 - 130mm (5 - 5.1 inches) and weighed between 7.5 - 7.7kg (16lb 7oz – 17lb). In all but one case the shot was cast with a visible raised cast line located equatorially and separate from the casting sprue at the top of the shot. The sprue takes the form of a circular dimple surrounded by a depression (Figure 6.40). The position of the cast line suggests a bipartite mould with joint aligned horizontally (Figure 6.40).

On several of the shot, but not all, either a makers or crown property mark, in the form of a crow's foot, was present between the casting sprue and casting line (Figure 6.40). This mark is very similar to the Broad Arrow mark. Presently it is not known with absolute certainty that the crow foot mark is the same as a regular Broad Arrow, which denoted crown property. Broad Arrows on shot, however, have been recorded on shot from the wreck of the fifth-rate *Dartmouth*, wrecked 1690 in the Sound of Mull and on the fifth-rate *Sapphire*, wrecked 1695 off Newfoundland, demonstrating that shot made for the Royal Navy was marked as Crown property (McBride 1976, p. 196).

The mark on the *Hazardous'* shot appears to be made by an angled blade, such as a chisel, which appears to be hammered into the shot after casting (Personal communication Alex Hildred, Curator of Ordnance at the MRT). This is opposed to the marking on the *Mary Rose's* iron shot, which had a raised H, demonstrating that the mark was cut into the mould and cast with the shot (Hildred 2011, p. 315). The latter made the preparation of the mould more complex and time consuming. The inventories show that by the 17th century, cast iron shot was supplied in much greater numbers and the *Hazardous'* shot demonstrates that the manufacturing method became cruder to speed up supply brought on by greater demand.

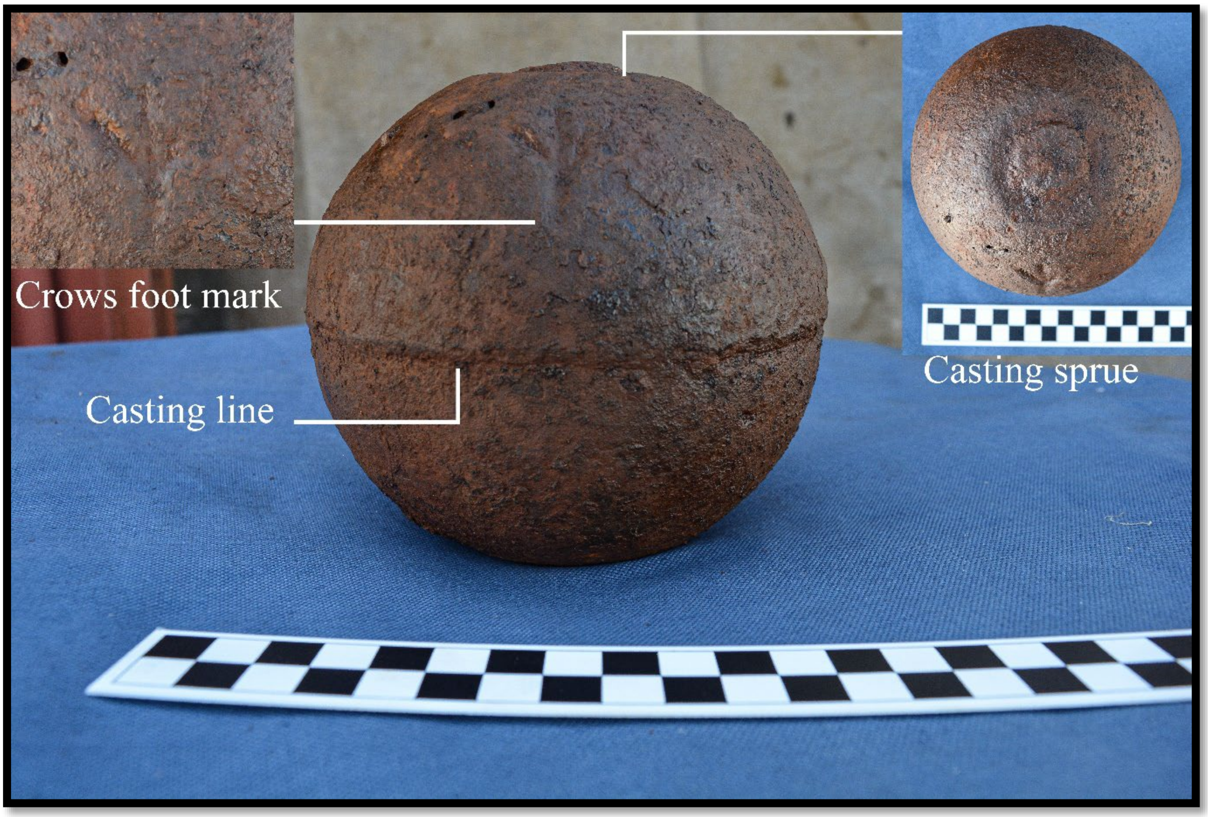

Figure 6.40: An 18-pounder shot showing casting line, casting sprue and crow foot mark (Photo by author).

The exception with the number of casting lines was an 18-pound shot that featured two casting lines, one located equatorially with the other 18mm (0.7 inches) below. It has a slightly different maker's mark too, in the form of a Y-shaped maker's mark, which is dissected by both casting lines. The casting sprue is separate from the casting lines as with the other shot (Figure 6.41). It is probable that the two casting lines were caused by two pours of molten iron with the first cooling enough to form a skin before the mould was topped up.

Figure 6.41: 18-pounder round shot HAZA009-20 showing casting lines, casting sprue and makers mark (Photo by author).

The 12-pounder shot that was recorded featured a lead plug next to the casting sprue (Figure 6.42). This is evidence of a poor cast, which left a void near the top of the mould. Instead of discarding the defective shot, either the makers at source or the crew, on inspection of the shot while on board, poured molten lead to repair and fill the void. The latter is possible, as McElvogue pointed out in his appraisal of the shot recovered from the Alderney wreck, due to the low melting point of lead making it easy to cast on board. The evidence for this comes from ingots or sheets of lead, along with melting ladles carried on board and found listed in inventories (McElvogue 1999, p. 15). The large depression around the sprue on most of the recovered shot is further evidence that could suggest there was haste in pouring the molten iron into the mould and that there was no equivalent to a feeding head to compress. This leaves a depression and sometimes a void, which is later filled as seen with the *Hazardous* example (Personal communication Alex Hildred Curator of Ordnance at the MRT).

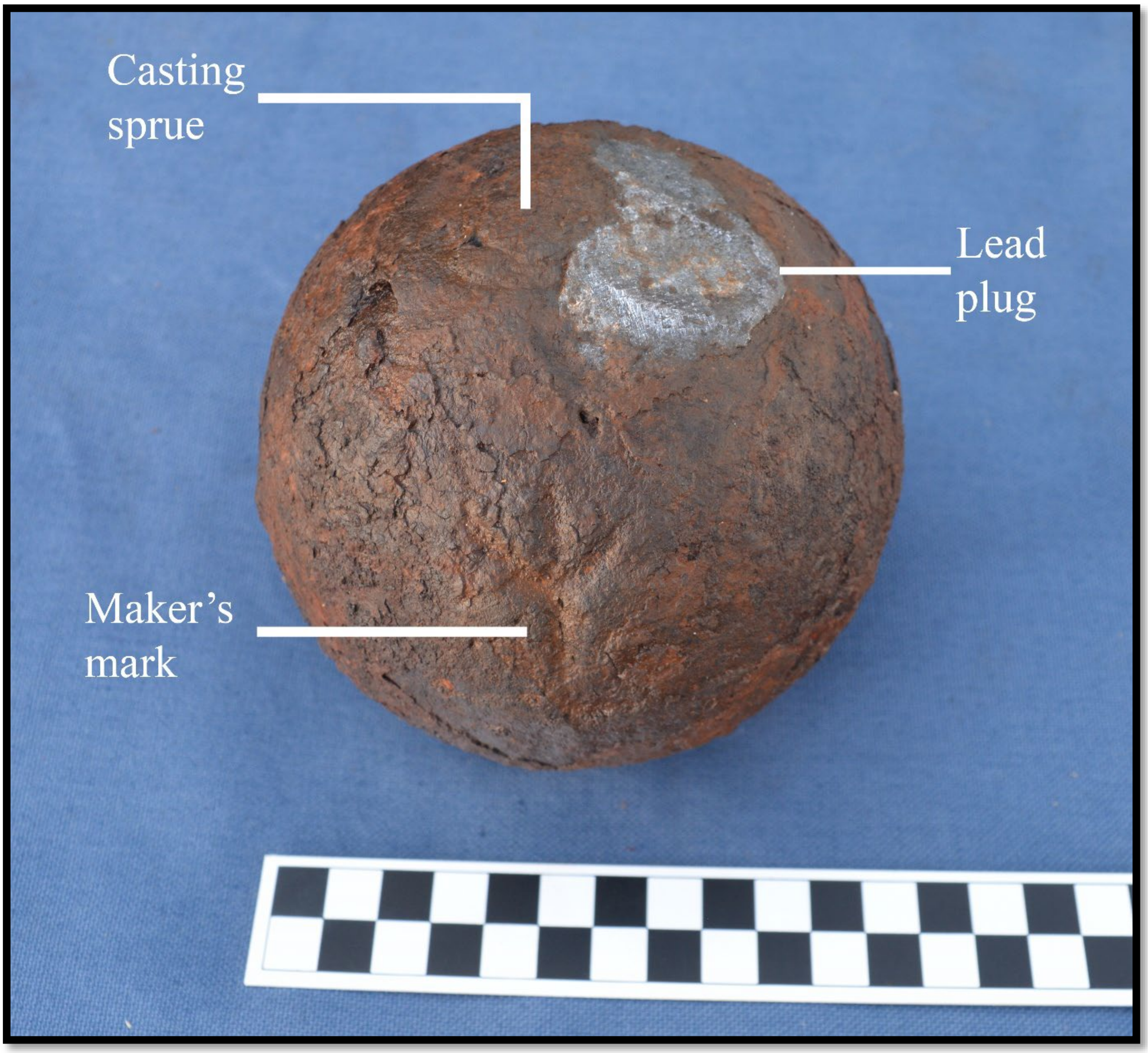

Figure 6.42: 12-pounder shot showing casting sprue, makers mark and lead plug (Photo by author).

Grape shot

The grape shot range in diameter from 47-49mm (1.9 – 1.93 inches). They have an equatorial raised casting line separate from the casting sprue. The casting sprue has in most cases a raised dimple surrounded by a depression. The position of the cast line suggests a bipartite mould with joint aligned horizontally. In some examples a broad arrow, cut or hammered by an angled blade, such as a chisel, is located between the casting line and the casting sprue (Figure 6.43). The size of the depression around the sprue suggests that the pour of the molten iron into the mould was rapid. The details on both the round and grape shot suggest they were produced by the same manufacture and the manufacturing process was conducted hastily, which may be a sign of the pressures put on by demand.

Figure 6.43: Examples of grape shot showing casting, sprue, casting line and broad arrow (Photo by author).

Double head hammered shot

The double head hammered shot are represented by seven samples recovered during the 2020 season (Table 6.4). Five were initially recovered, one from the main site, and two each from the 2014 and 2019 gun sites, and were then de-concreted. Prior to de-concreting, each example displayed a greater amount of concretion at one head than the other, which was matched when the concretion was removed (Figures 6.44 and 6.45). It was not entirely obvious whether this was a cause of the corrosion process or if they were deliberately manufactured to have one head bigger than the other. To determine the true size of the heads, two further samples were recovered from the 2019 gun site and CT scanned with the concretion left on. The results of the CT scanned confirmed that on both **HAZA0032-20** and **A0033-20** there was a difference in size between the two heads of the individual shot. The size difference ranged from 15-3mm. The CT scans also showed that the heads were dome shaped with rounded edges (Figures 6.46 and 47).

Artefact	Weight (Kg/lb and oz)	Total length (mm/inches)	Thickness of bar at centre (mm/inches)	Diameter Head 1 (mm/inches)	Diameter Head 2 (mm/inches)	Gun type
HAZA007-20	8.6kg/19lb	367mm/14.4in	51mm/2in	120mm/4.7in	102mm/4in	18-pounder
HAZA008-20	7kg/15lb 7oz	395mm/15.6in	47mm/1.9in	107mm/4.2in	102mm/4in	12-pounder
HAZA010-20	7.5kg/16lb 7oz	390mm/15.4in	52mm/2in	119mm/4.7in	116mm/4.6in	18-pounder
HAZA011-20	3.7kg/8lb 1oz	354mm/13.9in	37mm/1.5in	90mm/3.5	corroded	6-pounder
HAZA012-20	4.5kg/14lb 7oz	350mm/13.8in	45mm/1.8in	104mm/4.1in	80mm/3.1in	12-pounder
HAZA032-20	*NA	383mm/15.1in	42mm/1.7in	125mm/4.9in	110mm/4.3in	18-pounder
HAZA033-20	*NA	376mm/14.8	42mm/1.7in	119mm/4.7in	116mm/4.6mm	18-pounder

Table 6.4: Key weights and measurements for the double headed shot with appropriate gun type.*shot which was not de-concreted but was CT scanned.

Figure 6.44: **HAZA007-20** prior to de-concreting, note one end larger than the other (Photo by author).

Figure 6.45: **HAZAA007-20** following de-concreting. The scale in image is 20cm with 1cm increments (Photo by author).

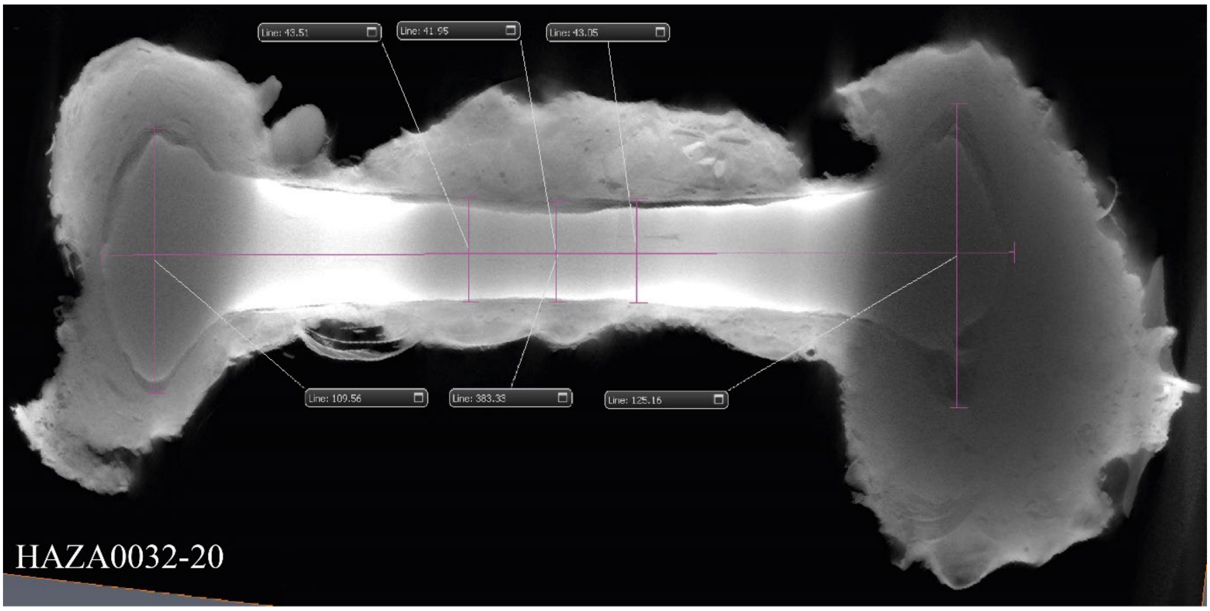

Figure 6.46: A CT reconstruction of **HAZA0032-20** showing the original shape of the shot (CT performed by the muvis imaging centre, University Southampton and courtesy of the HPG).

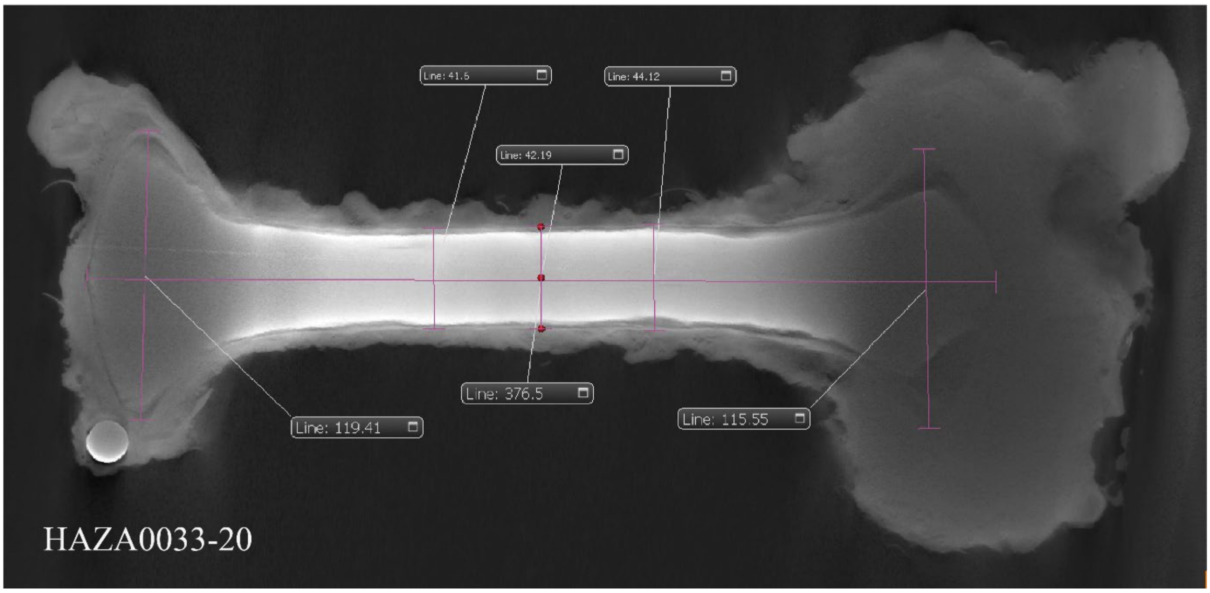

Figure 6.47 A CT reconstruction of **HAZA0033-20** showing the original shape of the shot (CT performed by the muvis imaging centre, University Southampton and courtesy of the HPG).

The seven samples consist of a bar of wrought iron, which can be seen from the obvious grain in the metal, and which has been hammered at each end to form a dome (Figures 6.45 and 46). In at least one example of the de-concreted shot, **HAZA012-20**, an additional wrought iron ring was present (Figure 6.48). This must have been hammer welded (when bar and ring were hot) around the end of the bar to form the domed head. This is apparent from the change in direction of the grain of the metal, which is perpendicular to the bar (Figure 6.48). The reason for this may be that the bar was deemed to be too short to hammer both ends and therefore a ring was added at one end to make up the size of the head. Of the seven recovered four have a dimension at the head suitable for the 18-pounder guns (**HAZA007, 10, 32 and 33)**. The length of these 18-pounder shot all differ, ranging from 395-367mm in length. The ranges in the length and diameters of the heads show that the manufacture of this type of shot was not an exact science. The inconsistency in the sizes of the shot of the same calibre can be attributed to the fact that they were all handmade and relied heavily on the eye of the blacksmith. The inconsistences in size also demonstrates they were made quickly due to large quantities being required to supply the navy. The difference in lengths of the shot, or differences of a few millimetres between the two heads of a single shot, may not have had a significant effect. However, differences of 15mm, as with the case of **HAZA0032-20,** might have cause the shot to rattle down the barrel of the gun, which if repeated by other similar shot may cause damage over time, plus the shot's trajectory on leaving the gun would be affected by the weight discrepancy, sending it off target. According to Povey the heads of the double head hammered shot should be equal to the height of the equivalent round shot (Povey 1702, p. 14), so the difference in size was probably a manufacturing error.

Figure 6.48: **HAZA0012-20** double head hammered shot showing the remains of a ring at one end (Photo by author).

6.4.3 *Powder*

Supply

Contemporary inventories show that a fourth-rate of 54-guns was issued with 220 barrels of gun powder (corn) (TNA WO55/1650). These barrels would have been stored in the main magazine in the forward part of the hold (Winfield 2005, p. 114). From there powder would have been transferred into cartridges in the filling room adjacent to the magazine and then transported to the gundecks when needed, within cases of wood (cartridge cases). A fourth-rate would have been issued with 44 cases of wood for the main and upper gundeck guns and 20 for the quarter deck guns (TNA WO55/1650).

Storage

If the internal layout of the *Hazardous* was altered during its refit to a ship of the Royal Navy, then the main powder magazine and adjacent filling room would have been in the forward area of the hold, aft of the foremast (Winfield 2005, p. 73). They would have extended across both the port and starboard sides, therefore, unless salvaged, the partial remains of the port side of these areas should survive within the main site. If the port side of the magazine and filling room have survived then they are currently buried, however artefacts associated with these areas have been recorded nearby suggesting the potential for these areas to survive. In 1988 an exploratory trench was excavated across the bow with the intention of better understanding the internal structure of that part of the ship. During the excavation artefacts were encountered including a fragment of a wooden cartridge case (Figure 6.47). A more complete example was found in 2016 (Figure 6.48) a short distance away, lying exposed between two floor timbers in an area consistent with the floor of the magazine or filling room.

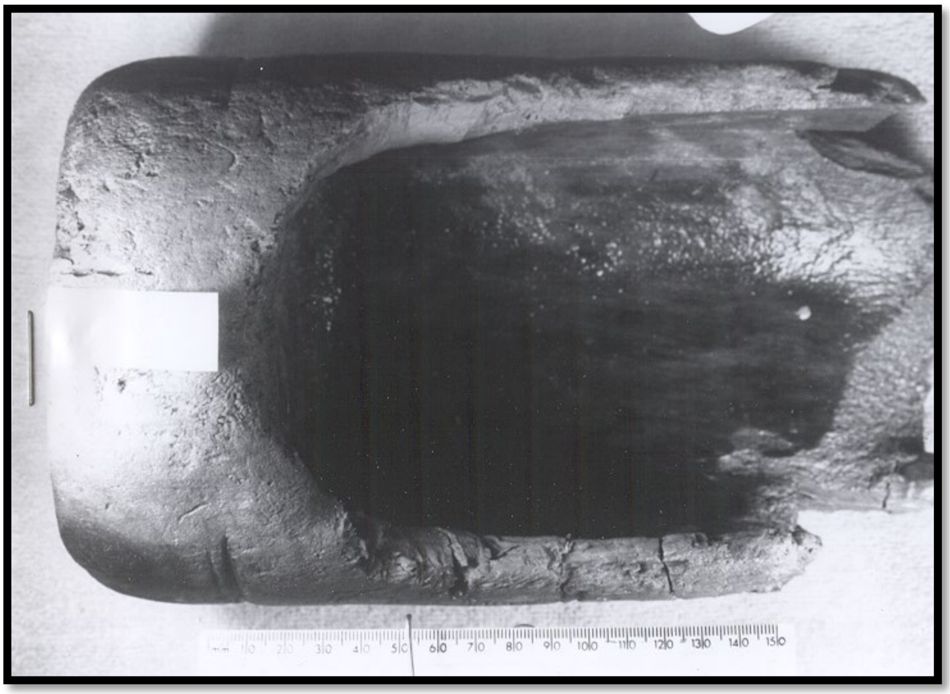

Figure 6.49: Fragment of a powder cartridge case recovered in 1988 (Courtesy of HPG).

HZA008-16 is a hollow cylindrical container with a solid base, turned from ash (Figure 6.48). Its external diameter is 180mm and its internal is 140mm (5 ½ inches) and its height is 510mm. There is an external collar, semi-circular in section, two thirds of the way to the top (Figure 6.50). The collar has a pair of drilled holes for the attachment of a lanyard. A similar example was found on the Duart Point wreck and dozens were recovered from the later wreck of the *Invincible*. The latter were found with flanged lids, which plugged into the top of their cases and the ones on *Hazardous* would have had the same. The lids had corresponding holes that lined up with the holes at the collar of the case. A looped lanyard would have passed through the holes on both the lid and the case, held in place at the underside of the collar by terminal knots. These cartridge cases, known simply as '*cases of wood for cartridges'* in gunner's inventories, allowed the safe transportation of powder cartridges from the filling room to the gun decks (TNA WO55/1650). The looped lanyard was an extra safety measure to ensure the lid stayed secured to the case, reducing the risk of exposing or spilling the powder charge during transportation. This task was described in Lord Wimbledon's Fleet Instructions of 1625:

'*That there should be one, two, or three men of good understanding and diligence, according to the burden of every ship, forthwith appointed to fill cartouches of powder, <u>and to carry them in cases or barrels covered</u> to their places assigned.'* (Corbett 1905, p. 29:Lord Wimbledon 1625/3/19).

The cases carried a single charge of powder calibre and the internal diameter of the *Hazardous* cartridge case was appropriate for a charge for an 18-pounder gun. The comparison between this one and the example from the Duart Point wreck shows their design had remained the same.

Figure 6.50: Cartridge case **HZA008-16** (Photo by author).

6.4.4 *Spare gun equipment*

Supply

The inventories show that multiple spares of every component of gunnery equipment were issued to ships of all rates and the exact quantity of those pieces represented by the examples found on the *Hazardous* are given in section 6.3 above. However, I would like to use this section to look closely at the wadding extracted from the barrel of the demi-cannon recovered from the *Stirling Castle* to see what it shows about the supply of wadding.

Wadding was an essential component of the loading process without which the gun would not fire successfully. A 1677 gunner's store list for a 54-gun fourth-rate shows that two imperial tons of junk for wadding were issued (TNA WO55/1650) and it is likely that some of that was made up of readymade wads. It is the makeup of the *Stirling Castle's* wads that were particularly interesting and potentially telling in the supply of the wadding on board the *Stirling Castle,* and which may have been a common occurrence.

The evidence from the *London* in section 5.3.4 has identified that by at least 1665 gun wads were constructed from individually picked yarns from old rope (junk) and wrapped roughly into a shape of a ball. This method would have taken time and considerable care, which could be the sign that they were made ashore and then issued to the ship readymade or, if on board, when there was sufficient periods of down time. The examples from the *Stirling Castle* are much cruder, made from picked strands rather than picked yarns, so the final phase of deconstruction of the junk has been omitted (Figure 6.51). These types of wads would have taken considerably less time and care to make. These poor-quality wads were then tied together with a piece of cord.

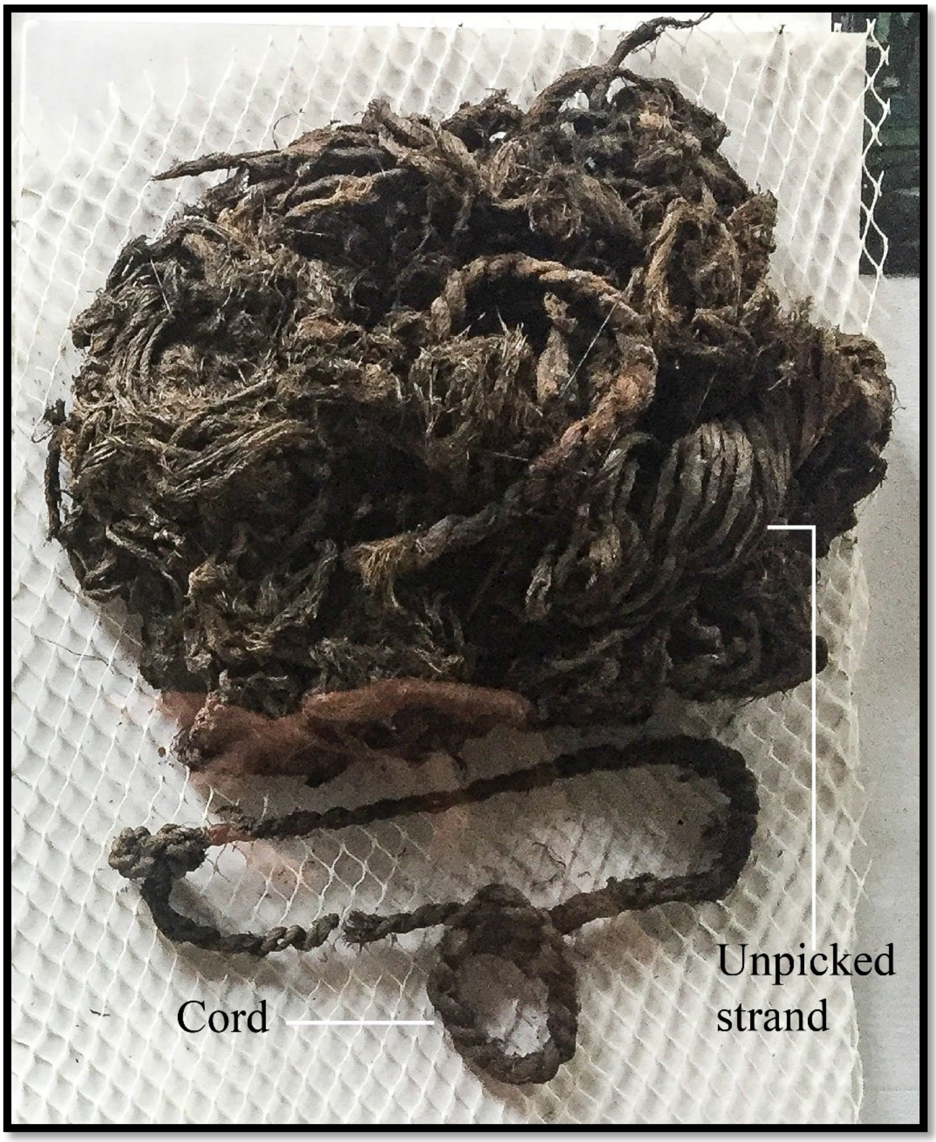

Figure 6.51: Wad from the *Stirling Castle* made from unpicked strands (Photo by author).

The historical records identifies that before the wrecking event the *Stirling Castle* had returned to England following a long campaign against the French, firstly based on the Atlantic coast at Lisbon and then in the Mediterranean (Martin-Leake 1919, pp. 118–126, Endsor 2004, p. 92). During the campaign the crews suffered from illness brought on by the heat (Martin-Leake 1919, p. 121) and the condition worsened on the voyage back to England with up to 1500 men dying in the fleet and three quarters of the rest so ill and weak that there was a lack of fit men to sail the ships (Martin-Leake 1919, p. 126). Given that there was a high potential that the *Stirling Castle* used up a large quantity of wads during the campaign, the crew would have had to make new wads from the junk. The combination of an unfit crew along with the probable haste to be ready for combat is an understandable explanation for the poor quality of the wadding made on board compared to those supplied readymade. This problem was probably not unique to the *Stirling Castle.*

Organisation

From the *Hazardous* only a small number of artefacts that can be associated with spare gun equipment have been found, and, although scattered, their general locations were in the forward end of the wreck. This would support what is understood from the historical record: that the gunner's store was at the forward end of the orlop (Winfield 2005, p. 114). Unfortunately, there is a lack of evidence from other sites, either because of the lack of surviving organic remains or lack of intrusive investigations undertaken where ships' structures survive intact. There is, therefore, the potential to increase our understanding of this aspect of the naval gunnery system through future archaeological investigations.

Evidence from the *Hazardous* does identify, however, that spare equipment was used during the ship's last operation and that there was another use for defective components. In 2014 sediments levels inside the main site reduced to an extent that it exposed several timbers. Their location was consistent with the hold and, on close inspection, the timbers were identified as consisting of two gun carriage axles and several medium sized pieces of round wood, still with bark attached (Figure 6.52). The latter were interpreted as logs for fired wood and they were neatly and tightly packed together.

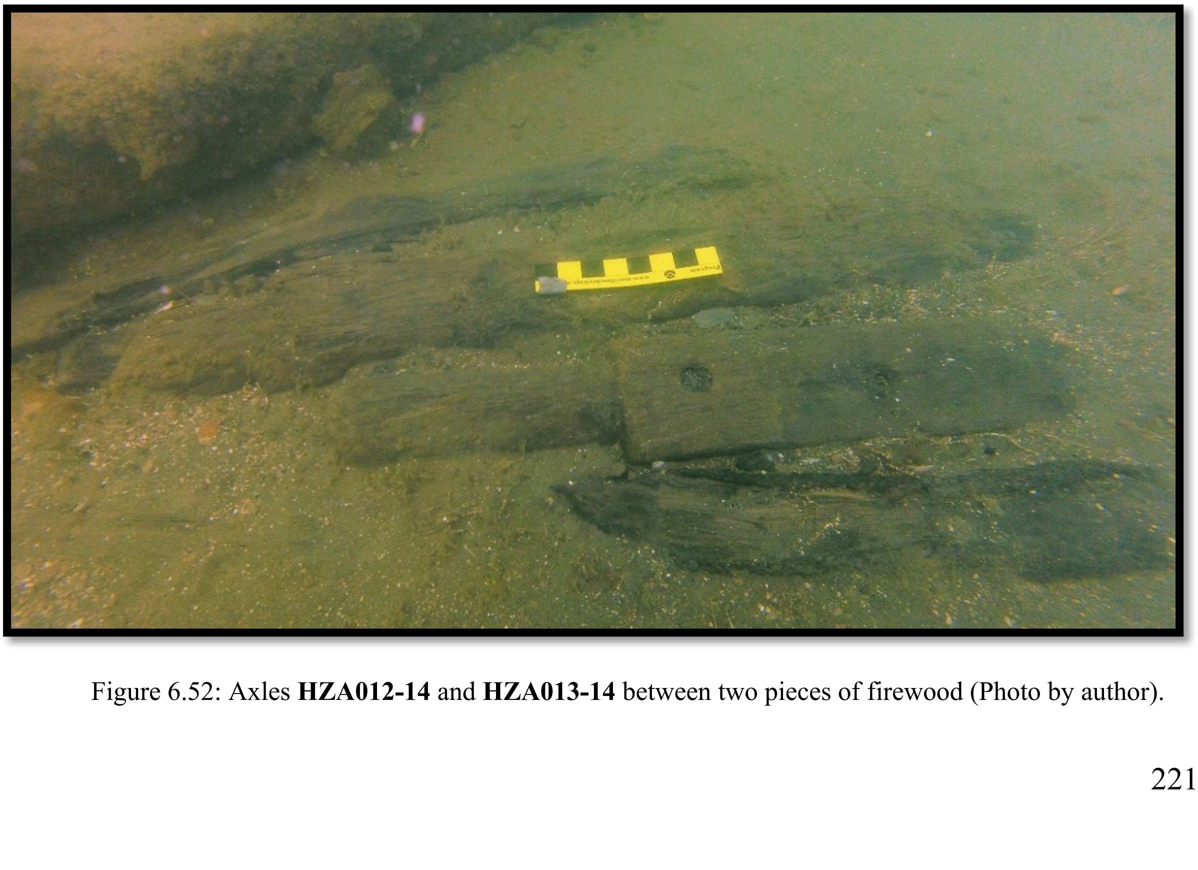

Figure 6.52: Axles **HZA012-14** and **HZA013-14** between two pieces of firewood (Photo by author).

The two axles were recovered, and the logs were left in-situ. During the recording of the axles it was evident that they showed signs of wear and tear. Axle **HZA012-14** was split at one end and the recess on the top side of **HZA013-14** was worn along with its right arm (Figures 6.10 and 11). The condition of both axles and their location alongside firewood in the hold demonstrates first, that there were spare axles to swap out for these defected ones and, second, that the broken ones were going to be recycled for other use, possibly as firewood. The location where they were found was in the forward area of the hold, possibly in a compartment to the port side of the magazine.

6.5 Key points

1. This is the period when the naval administration really stressed the importance of standardisation in the arming and equipping of the fleet. However, demand outweighed supply and it was still not always possible to fully arm vessels to the required standards. The *Hazardous* has demonstrated one way the Navy dealt with the problem, which was to re-issue the captured guns. On *Hazardous* these were a homogenous size on each deck, albeit French.
2. Where foreign gun calibres were similar in size to equivalent English guns the *Hazardous* has demonstrated that both English and French shot could be used.
3. The study of the distribution of shot has confirmed that significant quantities and types of shot were stored on the gundecks for immediate use and main supply of shot stored in a locker in the hold amidships.
4. The analysis of the shot has revealed manufacturing methods and that there was a significant degree of haste in the manufacture of all shot types, which may be evidence of the stresses to supply. The wrought iron double head shot from *Hazardous* has also identified other manufacturing habits.
5. As seen on the *London,* the *Hazardous* has also demonstrated the ability of the craftsman of the navy to adapt equipment to suit English methods of operating the guns. This was demonstrated through the additions of ring bolts on the French carriages.

6. The spare loading equipment has identified there was a particular but simple style to the equipment which had not changed from the time of the *London* but there may be signs of standardising the timber species used in the manufacturing.
7. There is evidence of use and re-use of spare equipment. It shows materials were recycled to maximise the use of materials on board. This was important when on long and distant voyages where supplies on board were limited.
8. The circumstances and pressures of being at sea during long arduous campaigns can affect the crew's ability or change their normal methods of doing things. This was demonstrated through the quality of wadding found in the gun from the *Stirling Castle.*
9. This chapter has revealed rich evidence for different methods of securing the guns when in transit or in adverse conditions and when space on deck was limited.

Chapter 7 The *Invincible* (1747-1758)

7.1 Introduction to the *Invincible results*

The focus of this chapter will be the archaeological evidence from the 74-gun *Invincible*, lost in 1758. The general period under investigation is from the mid up to roughly the last quarter of the 18th century. This chapter will include evidence from other shipwrecks and terrestrial finds, as well as historical and iconographic data spanning this period.

7.2 Introduction to the 2017-2019 site excavations

While five areas were strategically chosen for excavation during this period, it was Trenches 1-3 that revealed areas of the ship and artefacts integral to the different aspects of the *Invincible's* gunnery system. These include the operation, organisation and maintenance. Trench 4 was less relevant to the gunnery system but odd finds relating to gunnery were found in this trench.

The following sections, 7.2.1 – 7.2.3, will introduce the parts of the ship revealed in Trenches 1-3, identify which areas of the *Invincible* they are, and which specific aspect of the gunnery system they relate to. It should be noted here that Trench 1 had been partly excavated in the 1980s and the findings from that era will also be included. Trench 3 was also excavated in the 1980s and the current project returned to this part of the ship to record it in greater detail. It included the remains of the main gundeck and is therefore of particular relevance to understanding the operation of the guns.

Sections 7.3-7.4 will then discuss the evidence found on the wreck for working the guns and for the supply and organisation of the gunnery system. Evidence from other archaeological sites of the time will be incorporated, including contemporary historical sources and iconographic data. Finally, section 7.5 will summarise the key points.

7.2.1 *Trench 1, the port bow*

Trench 1 was located at the northwest end of the site, identified from previous investigations as the port side bow (Figure 7.1). These excavations revealed that the port side was healed over at 46º, calculated from the angle of the deck of the orlop (Bingeman 2010). This area was chosen for excavation because it was deemed to be a part of the site that was at-risk and vulnerable to physical and biological erosion, due to the natural loss of seabed sediments (Figure 7.1).

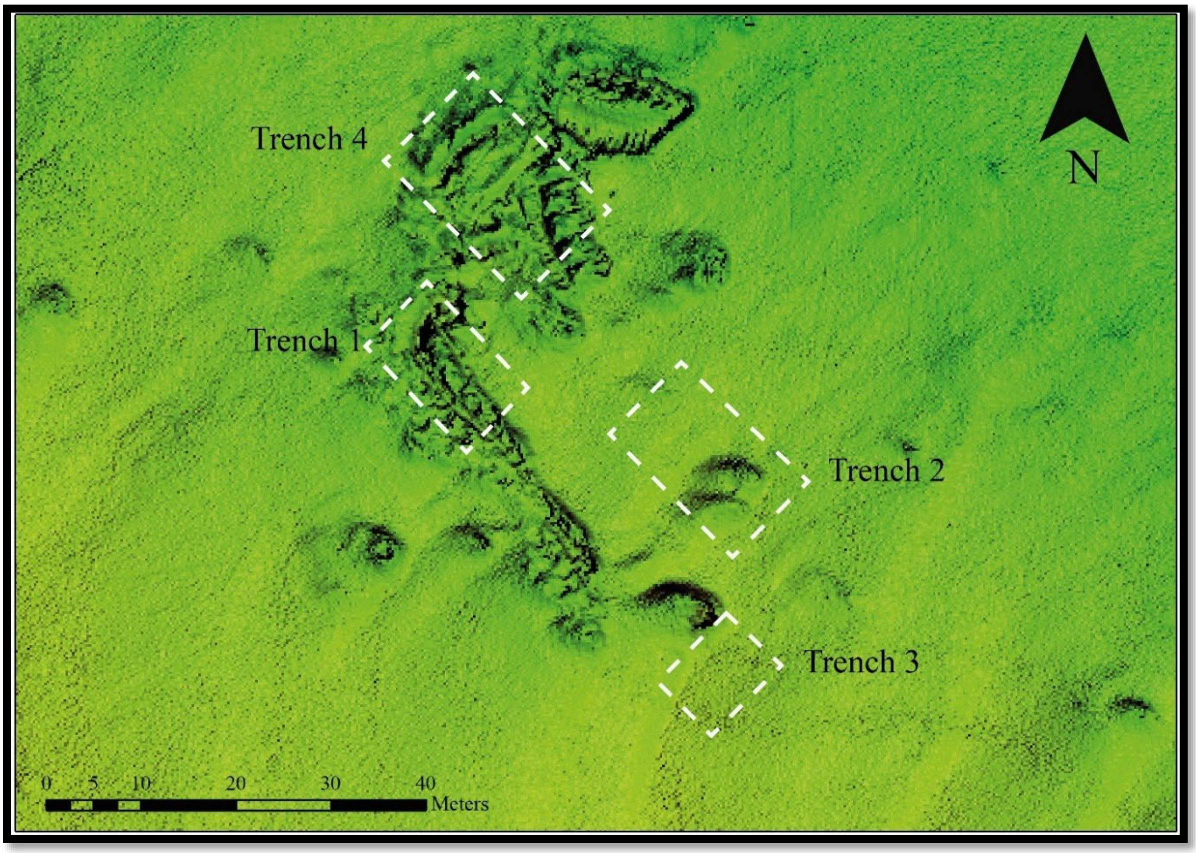

Figure 7.1:2018 multi-beam bathymetry image of the site showing position of Trenches and the extent of exposure (Courtesy of Bournemouth University).

A pre-disturbance survey in 2016 had recorded exposed hull structures relating to the main gundeck, orlop and hold (Pascoe Archaeology 2017a) (Figure 7.2). Exposed artefacts on the seabed, along with Bingeman's 1998 site plan, also indicated that this area had not been fully excavated (Bingeman 2010). The original plans of the *Valiant,* a 74-gunship based on the design of *Invincible,* shows this area of the ship accommodated the forward gun stations on the main gundeck, the gunners store on the orlop and the forward magazine and filling room on a raised floor in the hold (NMM J8137 and J8138). There was, therefore, high potential for finding artefacts and structures relating to gunnery in this location.

Figure 7.2: The 2016 photogrammetry survey of showing exposed parts of the gundeck, orlop and hold (Image courtesy of Pascoe Archaeology).

The excavation of Trench 1 was conducted during the 2017 and 2018 seasons. By the end of the 2018 season the port side bow had been excavated, revealing the internal structures from the remains of the forepeak extending 14m aft through the ship along the remains of the gundeck, orlop and hold (Figure 7.3).

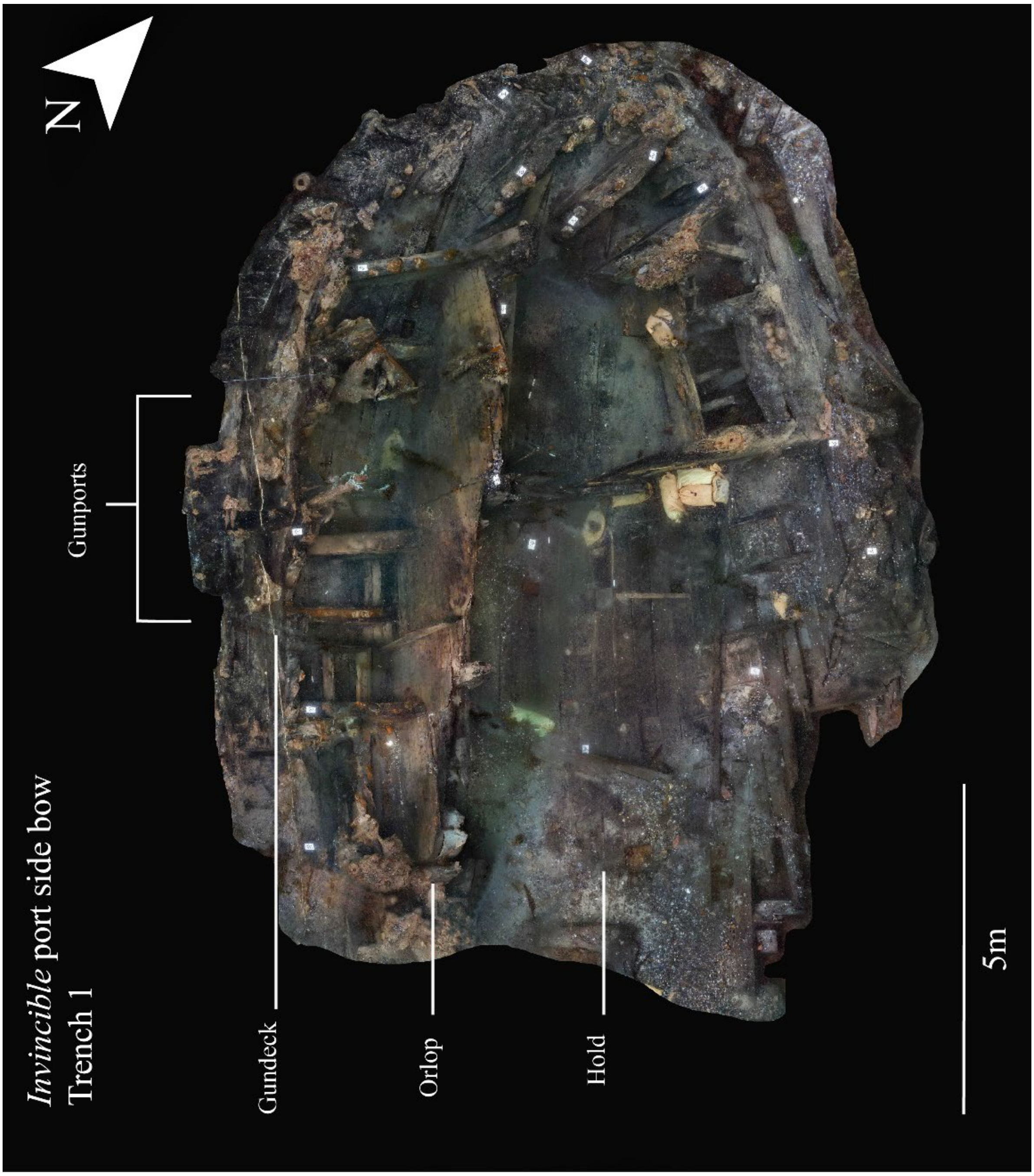

Figure 7.3: An orthophoto mosaic of the whole of Trench 1 with decks and areas of the ship annotated (The survey and model were produced by the author).

7.2.1.1 Main gundeck survival

The main gundeck of the *Invincible* was the location of the ship's main armament of 32-pounders, along with the gun's accessories and immediate supply of shot. The historical record has identified that the all the great guns were salvaged from the site along with their carriages (TNA ADM51/471). It is also likely that the gun's equipment on this deck was recovered because it would have been easily accessible. Despite these recoveries this part of the ship was considered relevant to this research as evidence for securing the guns could potentially still exist on the surviving hull structure.

On investigation it was found that the survival of the gundeck was poor and had deteriorated since it was first recorded during the 1980s and which is illustrated in Bingeman's publication (Bingeman 2010, p. 58). Despite its poor state of preservation, however, there were several discernible features of construction that were worthy of note (Figure 7.4): the remains of a single oak deck plank survived, extending from beneath the first gunport aft to the second gunport; a second layer of planking partially survived above the location of two supporting iron knees; beneath the remains of these planks are the eroded ends of deck beams, half beams and lodging knees; and, supporting the deck of the gunport, a total of three iron knees survive, bolted to the side of the hull.

Above deck level the forward-most gunport is clearly visible. The sill of the gunport is 0.75m above the deck and the port is 1.09mm wide, the sides survive to a height of 0.78m on the aft side and 0.45m on the forward side. Directly either side of the gunport are concretions. These concretions mark the positions of ring bolts, which were used to secure the breeching and gun tackle of the gun. The rings have not survived, only the remains of the broken bolts that lay flush with the inside of the hull. 0.78m aft of the gunport are the remains of a wooden rising knee. Aft beyond the rising knee are the remains of the second gunport; the height of the port barley survives above the level of the sill (Figure 7.4).

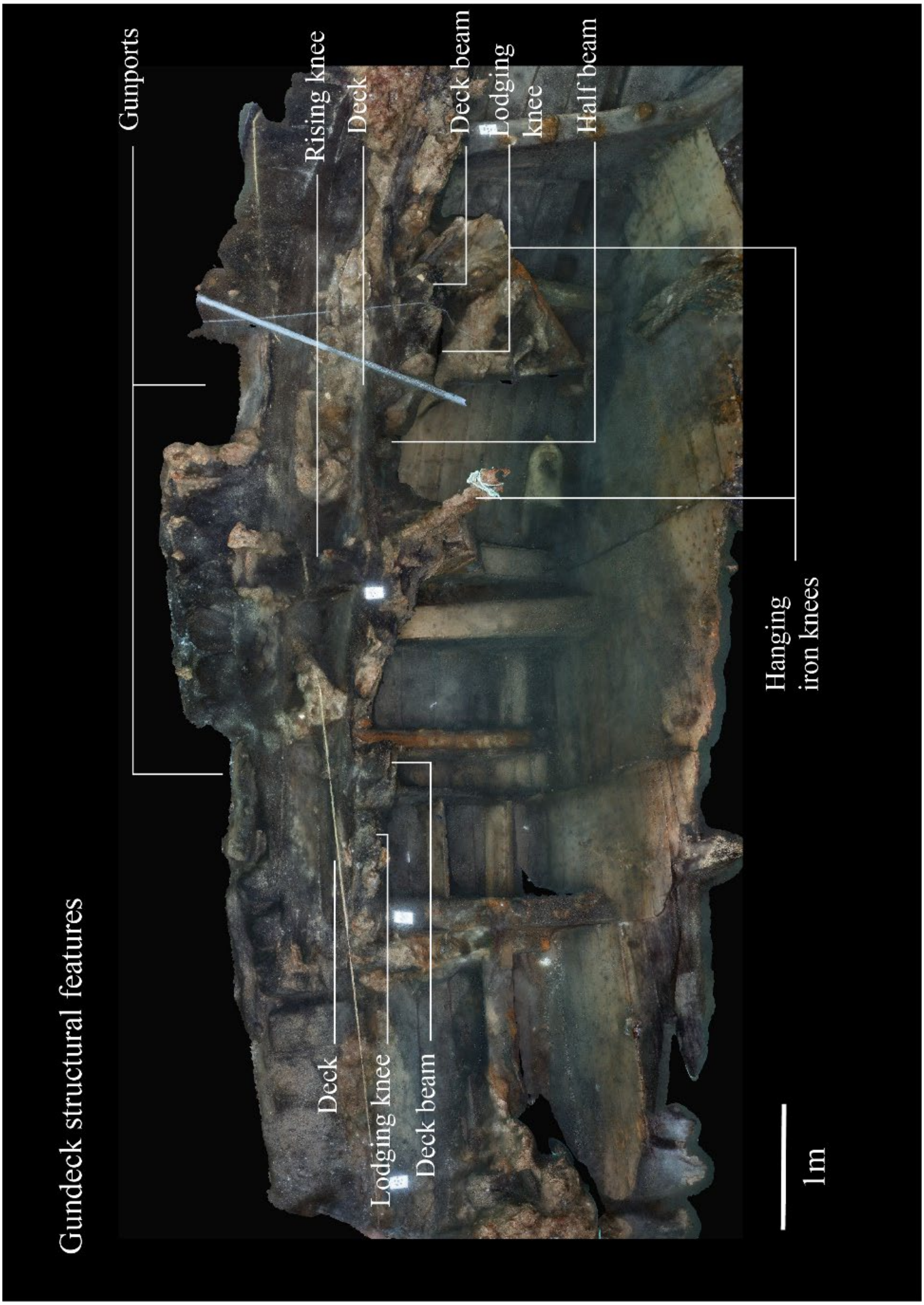

Figure 7.4: An Image taken from the 3D model of the port side bow, with focus on the structural features of the gundeck (Survey and model produced by author).

7.2.1.2 Orlop survival

The forward section of the orlop is where, according to internal plan of the orlop of the *Valiant*, the boatswain and gunner's storerooms were located, the gunner's store being the furthest forward and extending over to the starboard side (Figure 7.5) (NMM J8138). Both types of stores were recovered from this location during the 1980s excavations (Bingeman 2010).

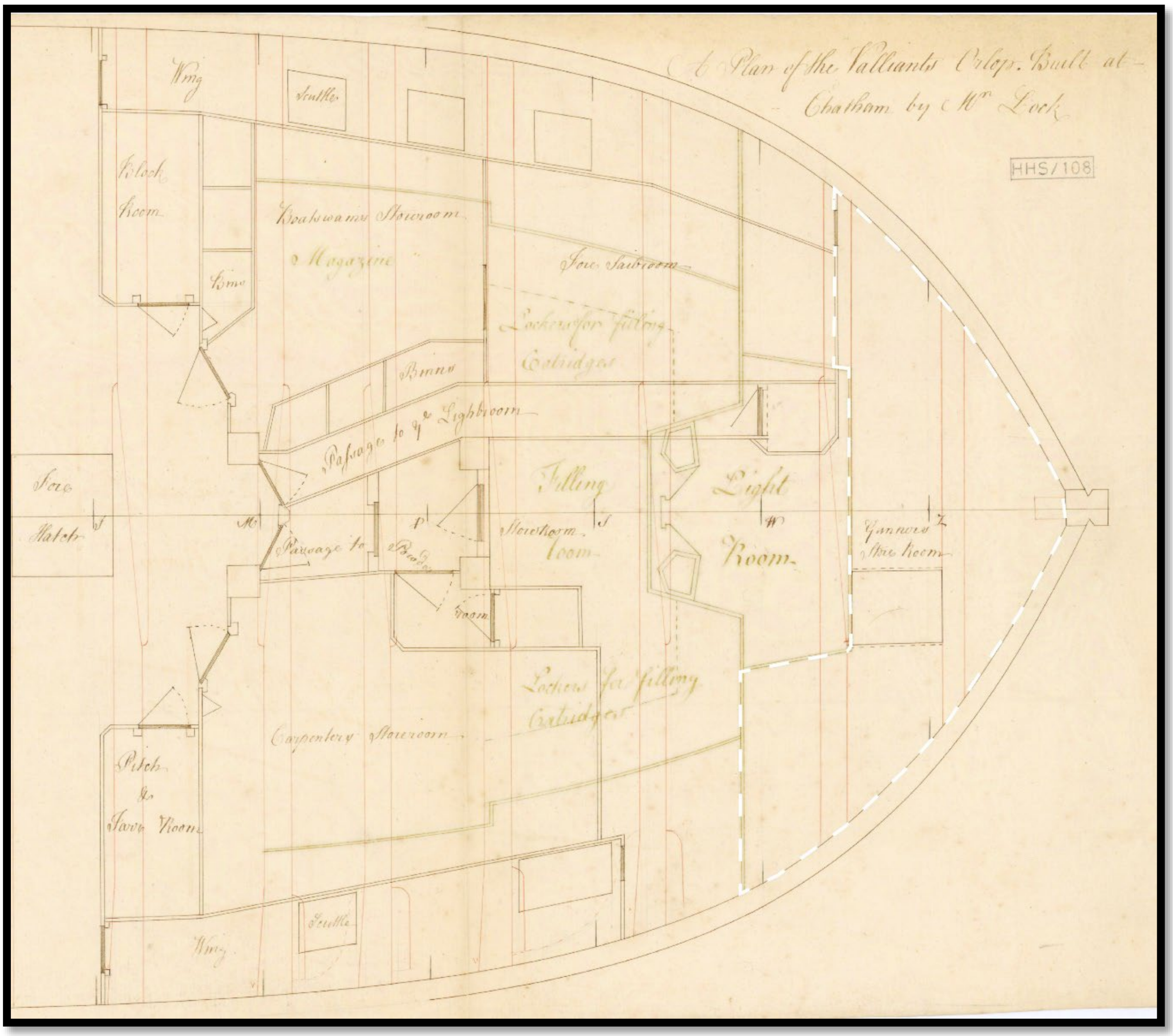

Figure 7.5: The orlop deck plan of the *Valiant* showing storerooms including the gunner's storeroom (outlined by white dashed line) at the forward end and extending across the port and starboard sides (Image J8138 © the NMM, Greenwich, London).

This area of the orlop is the most intact part of the wreck. The deck of the orlop survives from the bow 10.7m aft and at its widest is 1.95m (Figure 7.6). The deck is constructed from a layer of oak planks with a thinner layer of a light-coloured soft wood (pine) planking on top. The lighter planking is fastened to the oak beneath by iron nails. The lighter soft wood (pine) has also been used to clad the inside of the hull. This cladding is referred to as deal or slit deal in contemporary building contracts (TNA ADM106/3072) and, from the evidence observed on *Invincible,* is constructed by securing overlapping planks to battens fastened to the inside of the hull (Figures 7.6-7). The three hanging iron knees were also boxed-in using the lighter wood (pine) (Figure 7.8). The remains of a partition, which separate two stores, was also made of the lighter softwood (pine) as well as a series of three boxed shelving units on the inside of the hull (Figure 7.6). Within this section of the orlop are three rising knees. The forward-most rising knee is composite, constructed with two pieces of timber, one on top of the other and fastened into the hull by iron bolts. The rear piece appears to have acted as a packer, shaped to fit the curve of the hull. The next rising knee is 4.11m aft, sandwiched between two iron hanging knees. The rising knee is also clad with the lighter softwood (pine), as was the final surviving rising knee. It was not possible to identify whether the knee behind the cladding was made of wood or iron, although wood is considered most likely given that all other iron knees have been hanging knees. Evidence from *Colossus,* a British 74 gunship wrecked in 1798, similarly identified wooden knees clad with a thin layer of lighter softwood (Camidge 2002, p. 35). Here it is believed that the boarding over of the wooden knees was to keep out dampness caused by the ingress of seawater behind the boarding and therefore keep the stores and compartments dry (Camidge 2002, p. 35).

The deck of the orlop is supported and fastened to a network of deck beams, half beams, carlings, wooden lodging and hanging knees. At the forward-most section a dislodged hatch grating was found. This would have been lifted to gain access to the forward section of the hold below and is where the current excavation discovered other gunner's stores.

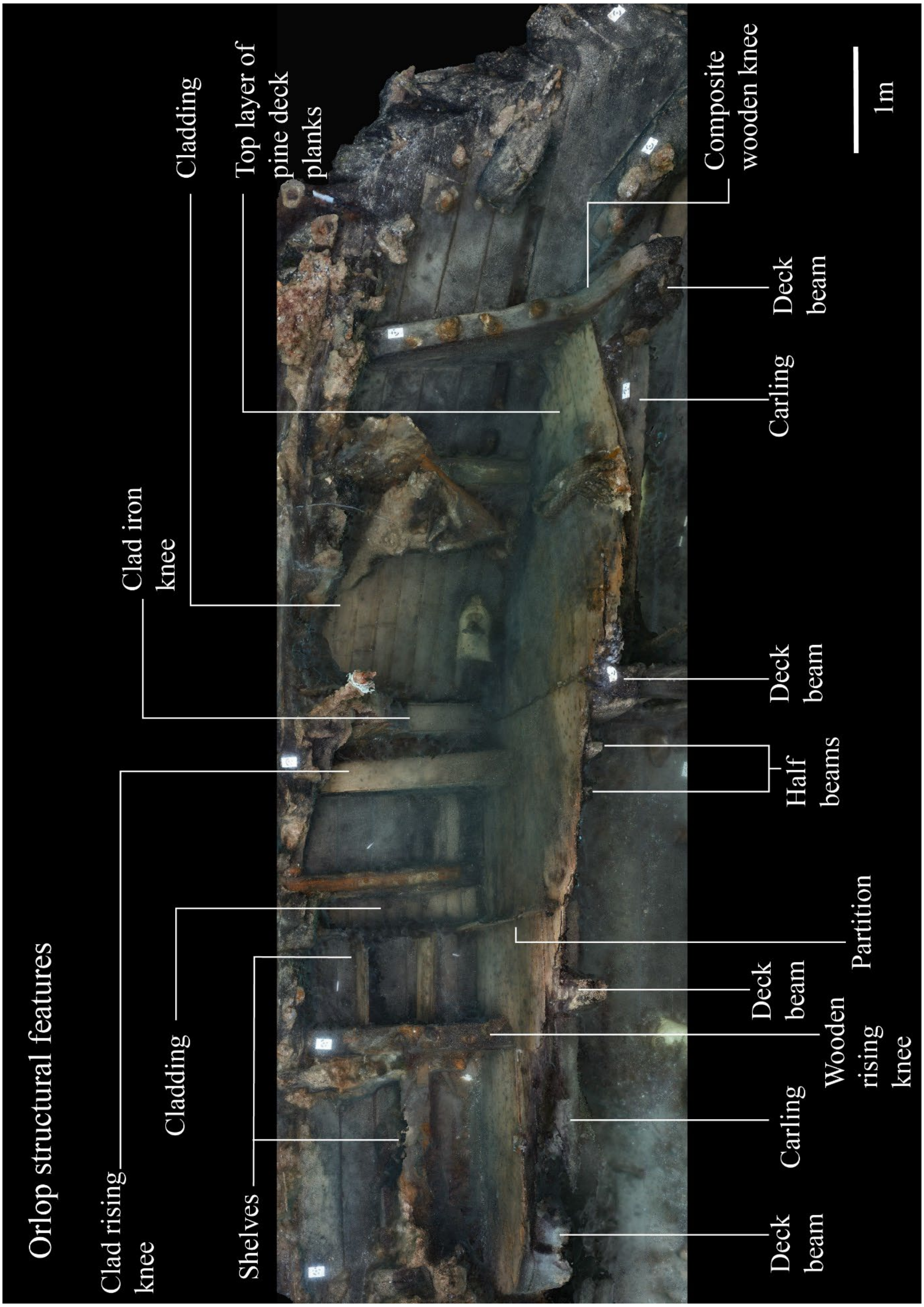

Figure 7.6: An image taken from the 3D model of the port side bow, with focus on the orlop structural features (Survey and model produced by author).

Figure 7.7: Cladding on inside of hull, notice how it is inverted (Photo by author).

Figure 7.8:Cladding around iron knee along the orlop (Photo by author).

The detailed description above is necessary because this was an area of the ship where the gunner's store was located. The cladding on the inside of the hull and the iron and wooden knees may actually be more relevant than one would initially think. The orlop and the hold are below the water line and water would have leaked through the many seams between the planks, meaning that these parts of the ship would have been quite damp. Keeping the powder dry in the magazine was essential, and will be discussed below, but it would also have been important to keep other stores free from damp to prevent rot. The overlapping cladding would have done just this: creating a thin barrier against the damp inner hull as well acting as a layer of insulation. Further evidence of this function comes from the inversion of the cladding, with the exposed edge of the overlap upside down (Figures 7.7-8). This inversion would have stopped water from coming through to the inside face of the cladding and thus kept the store dry, as well as allowing any condensation created from within the store to run out behind the cladding.

The overlapping and inverted cladding, therefore, would have helped keep a dry atmosphere within the stores and thus kept the spare equipment and stores in a good working condition. This would have been key to the maintenance of the gun's equipment and this exact type of inverted cladding was also recorded on the wreck of the *Colossus* (Camidge 2002). So far, these two sites are the only evidence of inverted cladding, demonstrating that this internal construction technique was in use on at least some Royal Navy vessels from at least 1758.

7.2.1.3 The hold

The forward-most part of the hold is known as the forepeak (Lavery 1987, p. 189) and the current excavation uncovered the hold from the forepeak extending 14m aft through the remains of the lightroom, filling room and main magazine (Figure 7.3).

The forepeak is a relatively small and tight space forward of the lightroom; a lot of the space in this area was taken up by three breast hooks (Figure 7.9). Lavery suggests this is where wood and coal was stored for the galley stove (Lavery 1987, p. 189), but the physical evidence from *Invincible* has identified that spare gun equipment was stored there between the breast hooks and with 'junk' lying on top and extending aft along a space on the outside of the lightroom (Figures 7.9-10). Junk is old rope and *Invincible* would have carried nearly seven ton of it for making wadding (TNA WO55/1745). Immediately aft of the forepeak were the remains of an internal compartment, which according to the plans of the *Valiant* and other plans of 74s, was the location of the lightroom (Figures 7.5 and 7.9-10) (NMM J8138). The purpose of the lightroom was to provide candlelight to the filling room and main magazine through a guarded glass window. It was constructed around the foremast on large warships (Lavery 1987, p. 146). On the wreck, beneath the raised floor of the lightroom, an eroded mast step was visible, demonstrating that the foremast would have passed up through the centre of the lightroom (Figures 7.9-10).

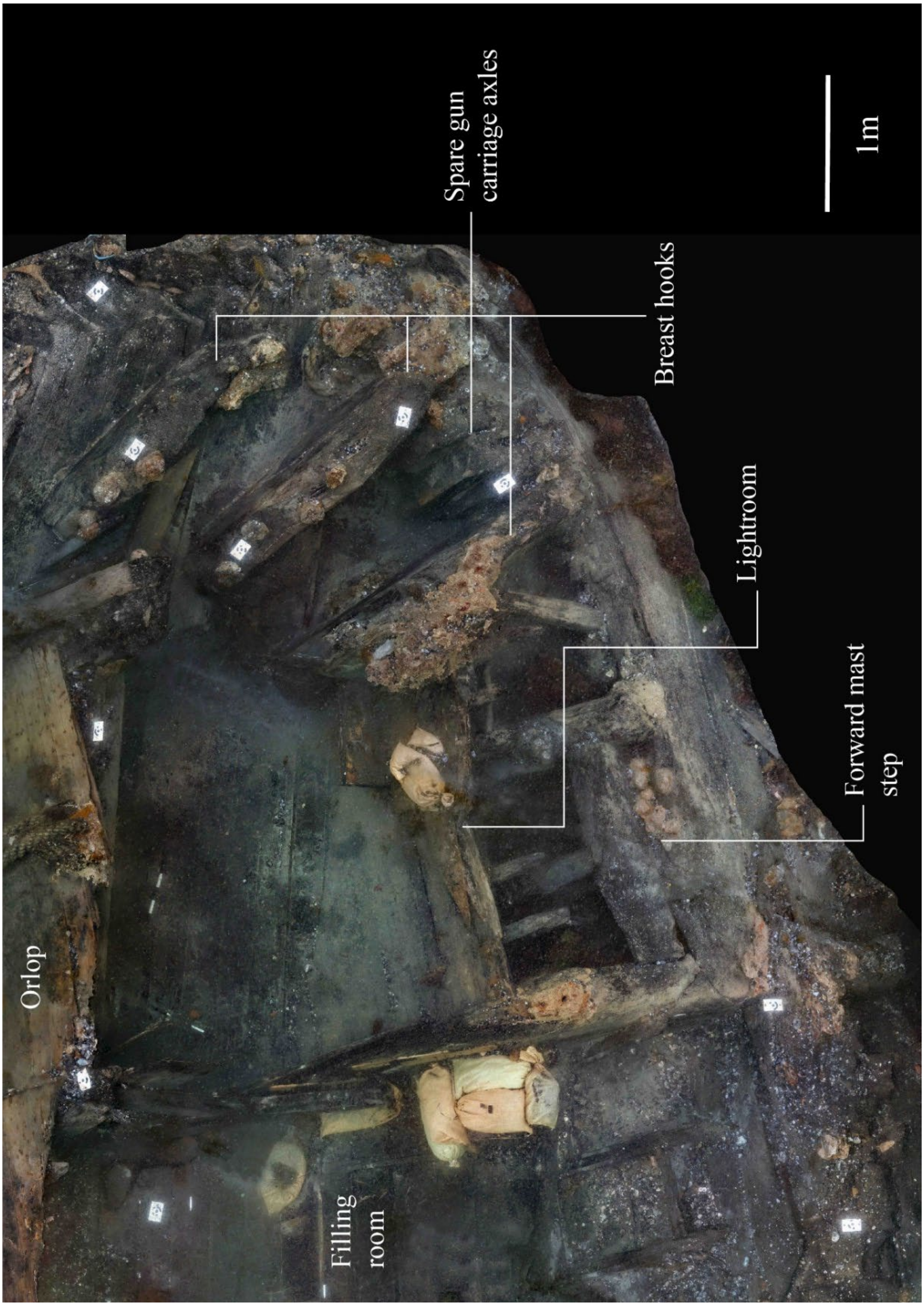

Figure 7.9: A close-up of the forward hold including the forepeak and the remains of the lightroom. Carriage axles still in-situ between breast hooks. Wadding and junk has been removed (Survey and model produced by author).

Figure 7.10: A still image from the 2017 photogrammetry model of Trench 1 showing the remains of the lightroom with wadding and junk outside the port side of the room (Survey and model produced by author).

A section of the floor and sections of the forward and port sides of the lightroom survive (Figure 7.10). The internal structures of the lightroom are constructed from a lighter softwood (pine) and the floor is raised over the ceiling planks and breast hooks. This raised floor is supported by oak half beams. Outside the port side of the lightroom was a space between the side hull and roof of the hold. Like the forepeak this was full of junk, but also with hundreds of gun wads, which will be described in more detail in section 7.3.4 (Figure 7.10).

A bulkhead consisting of oak planks and a layer of lighter softwood (pine) separated this area of the hold from the filling room and main magazine (Figures 7.9-10). The softwood was fastened to the oak by iron nails and between the two was a layer of plaster. The contract of a 70-gun warship dated 1755 described how the internal structures and bulkheads above and beside the magazine and filling room were lined and plastered for the security of powder (TNA ADM106/3072). There was no lining over the ceiling planks in the forepeak or the space to the port side of the lightroom.

Aft of the bulkhead was a large open space 6.7m long by 5.8m wide and up to 1.9m high. This was the location of the ship's main magazine and filling room (Figure 7.3 and 7.9, more detailed images in section 7.4.2). The internal structures of this area were dismantled in the 1980s and are now on display at Chatham Historic Dockyard (Bingeman 2010, p. 112). The forward section was the filling room, where the powder was transferred from barrels into paper or flannel charges and then into cartridge cases that would then be transported up to the gundecks. Immediately aft of the filling room was the magazine where the powder barrels were stored. Over forty powder barrels were recovered from this area in the 1980s (Bingeman 2010, p. 104). The current excavation found four barrels side-by-side on the floor immediately aft of the lightroom bulkhead. These barrels were stacked over wooden battens that maintained an air space between the floor and the barrels.

7.2.2 *Trench 2, bottom amidships*

Trench 2 was located over a small area of exposed iron round shot, which was surrounded by fine mobile sand and situated between the coherent port side and the broken starboard side (Figure 7.1). This position was chosen for excavation because the shot could have been overlying the remains of the lower hull and structures relating to the shot lockers. The shot lockers were located just aft of amidships either side of the main mast. Most of this area had not been located during previous investigations and its discovery provided useful information on how the shot was stored.

The excavation of Trench 2 revealed a coherent stretch of the middle section of the lower hull, 23m long and 10m wide (Figure 7.11). This section of the hull most likely survived because much of it was held down by the weight of the shot and, as the wreck broke up, the port and starboard sides broke away at the joins between the floors and second futtocks.

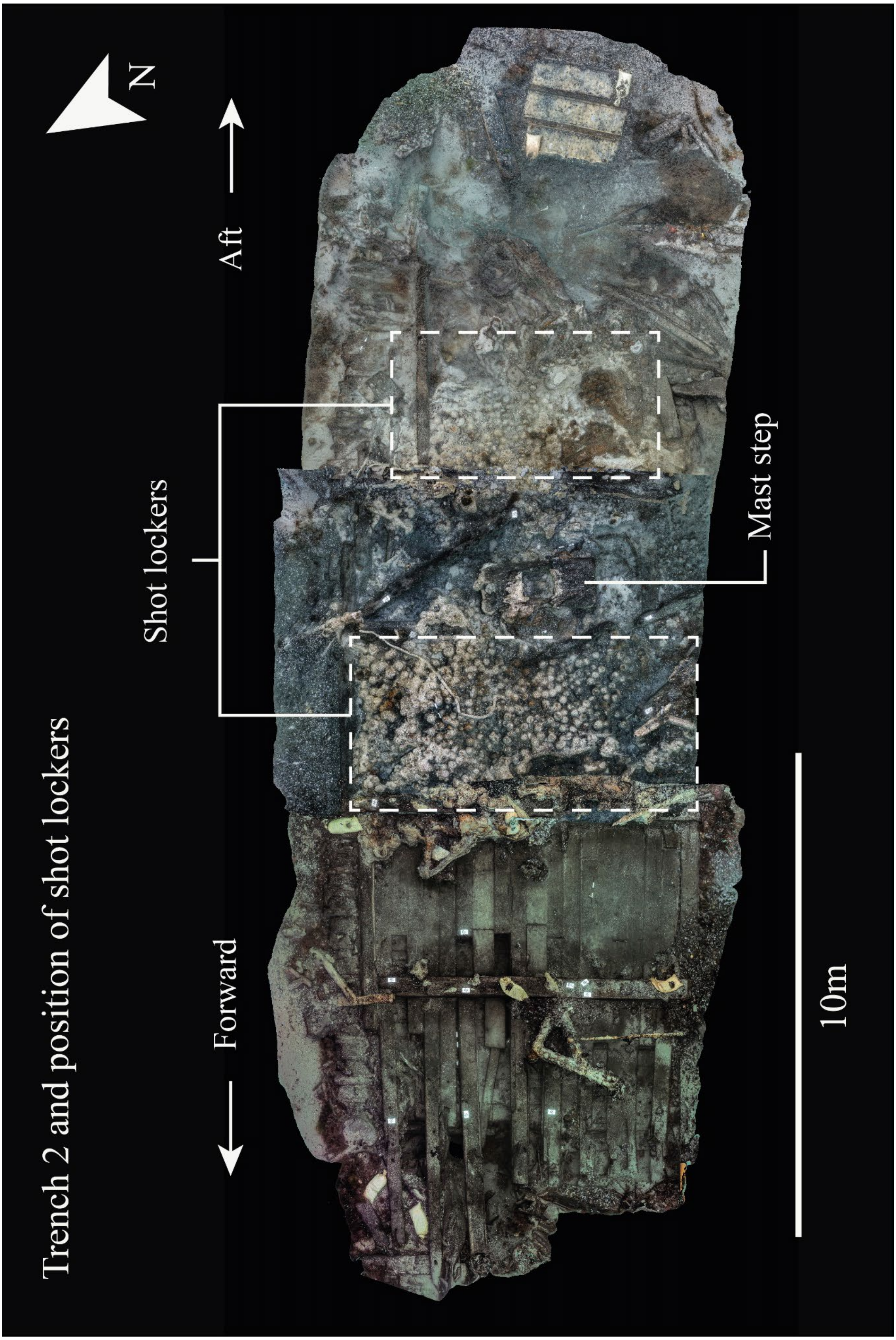

Figure 7.11: A photogrammetry model of the extent of Trench 2 in 2018 showing location of shot lockers (Survey and model produced by author).

7.2.2.1 Shot locker area

The extent of the uncovered shot was clearly contained within an 11m by 7m section of the lower hull around the area of the well and main mast. The location of the main mast step confirms this, albeit slightly off the centre line (Figure 7.11). This area of shot can be divided into two distinct areas: one forward of the mast step and the other aft of the mast step (Figure 7.11). This corresponds with a contemporary building contract of a 70-gun ship which states,

''*To have shot lockers*, *one afore and another abaft the well''* (TNA ADM106/3072).
This area, and the distribution and type of shot, will be discussed in more detail below.

7.2.2.2 Lower hull structure and hold area

Forward of the shot was a clear area of lower hull structure 10.5m long by 7m wide. It consists of ceiling planks on top of framing with two single riders traversing the inside of the hull. At the centre line of the hull was the keelson and either side of the keelson were moveable limber boards. When removed they exposed the framing of the ship beneath. The hull structure at the aft end of the shot was very badly broken up (Figure 7.11).

7.2.3 *Trench 3, port stern*

Trench 3 was located at the southeast end of the site (Figure 7.1). This area of the site was identified during previous investigations as the stern port quarter, from the main gundeck down to the floor of the ship (Bingeman 2010). The current excavation of Trench 3 uncovered a section of hull 10m long fore and aft and 11.4m wide from gundeck to the bottom of the hull. (Figure 7.12).

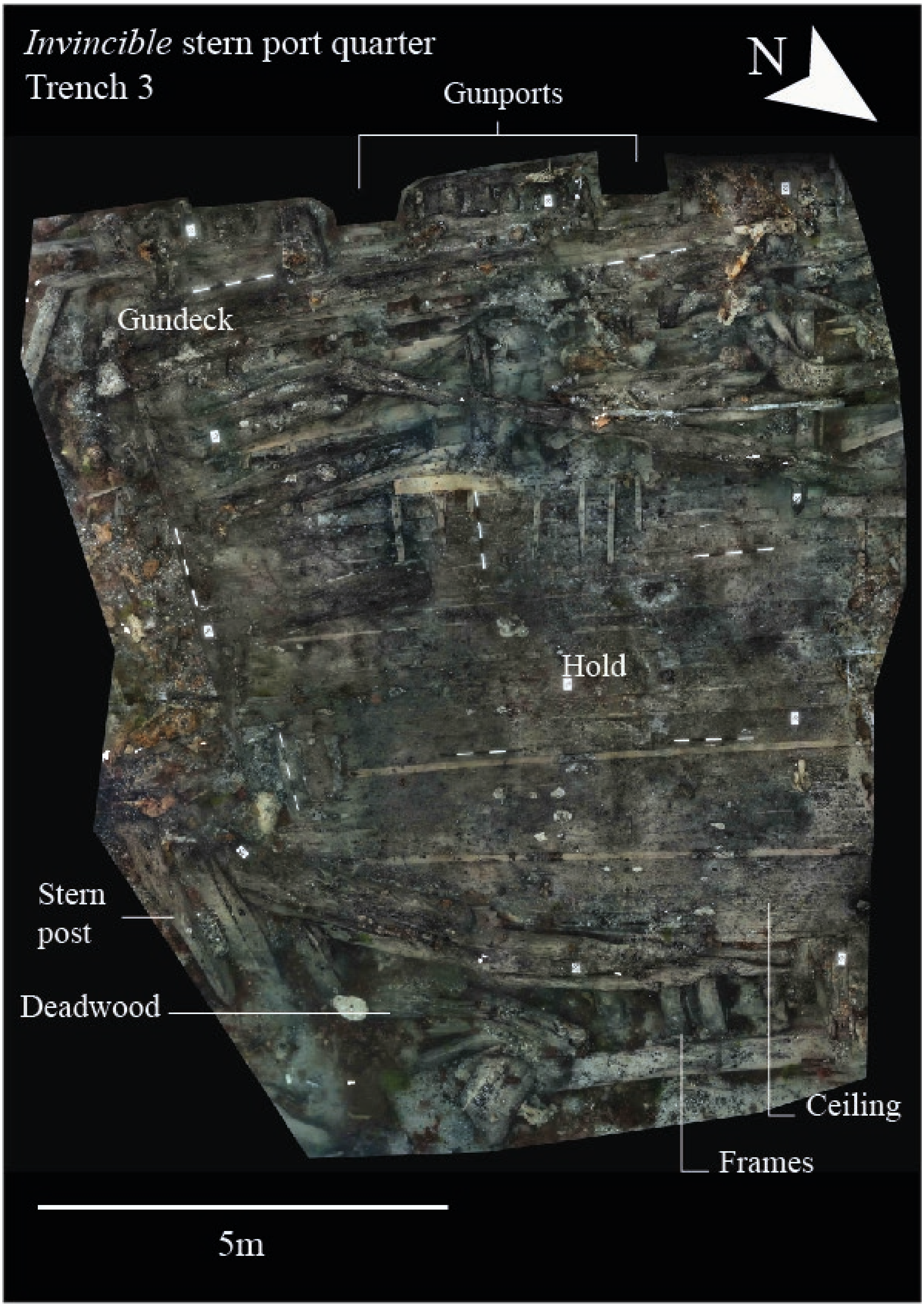

Figure 7.12: An orthophoto mosaic of Trench 3 which represents the stern port quarter from gundeck to the bottom of the hull (Photogrammetry survey, and ortho by author).

7.2.3.1 Main gundeck survival along the stern port quarter

As previously mentioned in section 7.1.2.1, the *Invincible's* main gundeck accommodated the ship's main armament of 32-pounders. This area of the main gundeck was known as the 'gunroom'. The actual deck of the gundeck does not survive but the location of where it met with the side of the hull can be seen. The inside of the hull survives in reasonable condition with two clearly discernible gunports (Figure 7.12). These gunports have fared much better than the gunports at the bow, with the remains of concreted ring bolts surviving on either side of the ports. These ring bolts will provide some of the evidence for how the guns were secured to the inside of the hull. The stern most gunport is 0.68m above the level of the deck and is 1.06m wide, surviving to a height of 0.75m. It has the remains of four concreted ringbolts, two on either side of the port. The next gunport aft is 0.66m above the deck, 1.07m wide and survives to a height of 0.75m.

A large transom knee passes under the aft-most gunport. This would have stopped the gun being fully run-out and may have been a hinderance when reloading the gun. Below the transom knee it was possible to see the location of the deck. Between the location of the deck and the transom knee was broken pine cladding, suggesting at least the lower sides of the gundeck were also clad with pine. The 'gunroom' was initially a place where the Master Gunner had his living quarters but the increasing number of people on board by this time meant that this room was shared with other warrant and inferior officers, such as midshipmen (Rodger 1986, p. 67). It was also where the tiller entered the stern of the ship from the top of the rudder. With the tiller, large transom knees on either side of the hull and 32-pounder guns, space would have been limited in this area of the ship. This pine cladding would have reduced dampness and acted as a layer of insulation, therefore offering some comfort to those who slept in these cramped conditions.

7.2.3.2 The Hold/bread room

At the stern directly below the gundeck there is no orlop, which ends just beyond the location of the mizzen mast. The hold, therefore, starts from the bottom of the gundeck and extends down to the floor. This area of the hold was known as the 'Bread room'(Lavery 1987, p. 189). The evidence from *Invincible* shows at least the upper parts of the area of the hold were clad with a soft wood (pine). It is evident that the soft wood was fastened to battens and the battens were fastened to the ceiling planks. The inside of the hull survives in good condition all the way down to the centre line of the stern. A section of the stern post survives along with the stern knee and keelson on the inside (Figure 7.12).

7.3 Evidence for working the guns

The evidence for working the guns comes predominantly from the equipment needed to mount, load, manoeuvre and fire them. When in-use this equipment would have been found alongside the guns on the gundecks. The guns and associated equipment were, however, salvaged from the ship within a few days of the ship running aground in 1758 (TNA ADM51/471). Both Bingeman's and the current excavations, however, have shown that much of the spare gun equipment was left behind, along with fixtures and fittings surviving on the inside of the hull of the main gundeck. This next section will identify the equipment found and describe the role it played in the operation of the great guns. The equipment discussed below came mainly from storage areas associated with the gunner's stores, their function and form will be discussed here with a brief mention of where the objects were found. The location and organisation of these stores will be discussed in more detail in section 7.4: 'supply and organisation'.

7.3.1 *Mounting and supporting the guns*

Carriages and carriage components

The type of carriage issued to British warships during this period has been referred to as the truck and axle carriage (Lavery 1987, p. 127) or the bracket and transom carriage (Caruana 1997, p. 366). Essentially, the bed of the carriage was dispensed with and replaced by more robust axles and a block of timber, known as a transom, breast bed or chuck, which was placed between the cheeks at the front of the carriage (Mountaine 1747, p. 65, Muller 1757, p. 164) (Figure 7.13). This first appears to have occurred *c.* 1725 (Lavery 1987, p. 127, Caruana 1997, p. 363). No longer having a solid bed reduced the weight of the carriage, with the sturdier axles and transom piece maintaining strength and integrity. The reduction in weight would have been extremely beneficial on board ship.

Invincible would have been issued with the bracket and transom carriage for all the ship's great guns. Several of these carriages had to be altered prior to being issued to compensate for the height of the *Invincible's* ports above the deck (HCCA 109M91/CO12 and 109M91/CO16). The guns and carriages were all salvaged from the wreck within days of the ship going aground, but evidence still survives of the type of carriage on board the ship through the discovery of spare carriage parts, found stowed within the forward hold. Although not all parts of the gun carriage are represented within the *Invincible* assemblage, there is evidence from other wrecks and terrestrial sites that can provide a more complete picture of this type of carriage. This will be discussed later in this section.

The cheeks of bracket and transom carriage were each constructed from two pieces of timber that were secured by iron bolts. These bolts passed down from the top side through the two pieces. It would appear from the archaeological evidence of 18th century carriage parts from Woolwich (Figure 7.14), a recovered gun carriage from the first-rate ship of the line, *Royal George,* wrecked in 1782 (Figure 7.13), along with contemporary illustrations (Caruana 1997), that the cheeks were secured by up to six vertical bolts each. From contemporary illustrations and texts, five bolts would appear to be standard but the evidence surviving on the right cheek of a 42-pounder carriage, recovered from Woolwich, shows six bolt holes (Figures 7.14). This is not unexpected as 42-pounder carriages were the largest and it is no surprise that an extra bolt was needed to secure the two parts of the cheek.

Starting from the head of the carriage, the first iron bolt, known as the start bolt (Mountaine 1747, p. 65), passed down through the top of the cheek and front end of the capsquare at a slight incline, all the way through to the underside of the front axle. The second bolt, known as the capsquare bolt, passed down from the top, through the rear end of the capsquare and through to the underside of the cheek. A third bolt passed down from the top of the first step and through to the underside of the cheek, again slightly inclined. The last two bolts, known known as the axle-tree and tail bolts, passed down through the rear steps and through to the underside of the rear axle. A ring and forelock was placed at the bottom of each bolt to secure it in place (Mountaine 1747, p. 65).

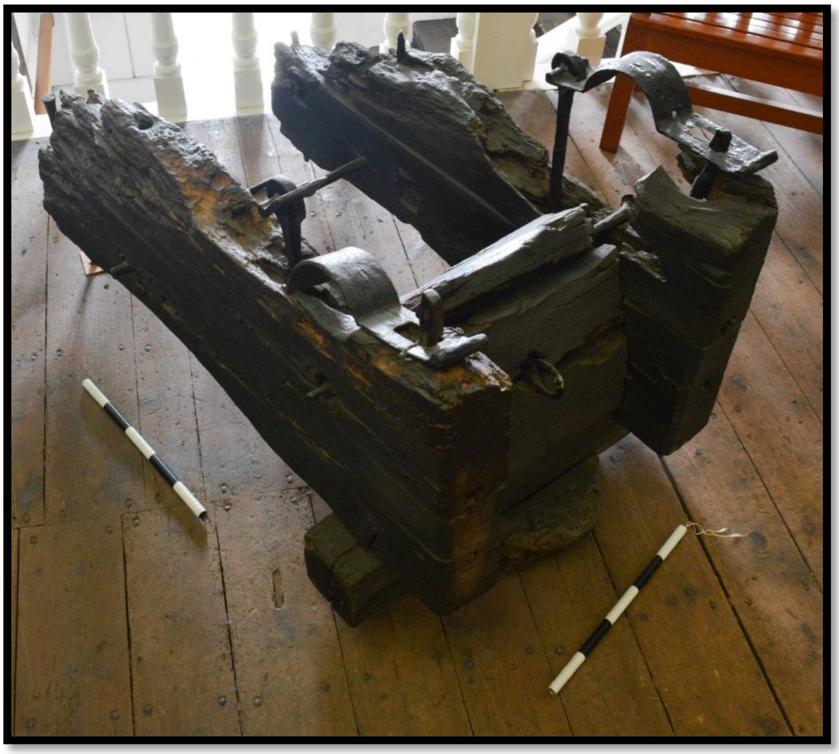

Figure 7.13: Example of a truck and axle carriage recovered from the wreck of the *Royal George* 1782 and now at the NMRN (Photo by author).

Figure 7.14: The right cheek of a 42-pounder carriage. A) Showing the cheek is made of two separate pieces and B) shows the lower section with location of six bolt holes. This example was recovered from a terrestrial site at Woolwich. The scale is 0.5m with 10cm increments (Photo by author).

The archaeological evidence from the *Royal George* and from Woolwich identify that a shallow arch was cut into the underside of the cheeks between the axles. This was probably another way of reducing the weight of the carriage without compromising the strength (Figure 7.14). The Woolwich rear axles have an eye bolt attached to the rear face of the rear axle (Figure 7.15). This was known as the after bolt (Mountaine 1747, p. 66). This eye bolt was where the train tackle was connected to the rear of the carriage. The single eye bolt was a change from the two ring bolts located on the rear corners of the old carriage with a solid bed. The obvious advantage with a single attachment point was there was only the need for one train tackle and therefore less tripping hazards across the deck.

Figure 7.15: An example of a rear axle recovered from Woolwich show the after bolt, which would have been used to attach the train tackle (Photo by author).

The archaeological evidence and contemporary plans identify that the design of the front and rear axles were different (Figures 7.15 and16). The rear axles have a wider upper surface to support the breech of the gun and provide a platform for the rear end of the stool bed. Recesses were also cut into the rear axle for the cheeks to slot into to form a strong and stable joint. The trucks fitted onto the end of the axles and were secured in place by linchpins (Figure 7.15). Finally an iron hoop was placed at the ends of each axle to prevent splitting (Mountaine 1747, p. 66).

Figure 7.16: Example of a front axle recovered from Woolwich. Note how it is much narrower than the rear axles (Photo by author).

The iron work on the outer faces of the truck and axle carriage was very similar to that of the older bed carriage. The exception would be the location of the iron through-bolts that provides strength between the two cheeks of the carriage. As the solid bed had been removed the through-bolt between the cheeks was located lower down, so a stool bed and coin could be supported (Figure 7.17). This was known as the bed bolt and it served to secure the cheeks and provide a rest for the fore end of the stool bed (Mountaine 1747, p. 65). The stool beds recovered from the *Invincible* have a notch cut into the underside of the fore end, which would slot over the bed bolt (Figure 7.18).

Figure 7.17: Photo showing the bed bolt between the two cheeks of the *Royal George* carriage. Note that the rear section including rear axle was missing from the carriage (Photo by Author).

Figure 7.18: Example of a stool bed recovered from *Invincible* (Photo courtesy of J. Bingeman).

As mentioned above, the carriages along with the guns were salvaged shortly after the ship ran aground. However, ordnance store lists show that 74s for foreign duty were issued with spare axles and trucks, which were two major parts of the carriage, and the pieces of the carriage most likely to break under the strain of the guns. The axles and trucks were divided into fore (forward) and hind (rear). There would have been two spare fore and hind axles and four pairs of forward and two pairs of hind trucks for the main and upper deck guns. For the guns on the poop and quarter deck there would have been one spare fore and hind axle and two pairs of fore and one pair of hind trucks. That would have made 10 spare axles and 46 spare trucks in total (RUSI/6 and TNA WO55/1745).

A total of eight spare gun carriage axles were found in Trench 1 sandwiched between two breast hooks in the forepeak. No spare axles were found during the earlier Bingeman excavations. All of the axles had one end of the axle eroded away but the sections of the axles that have survived are in a good state of preservation. Their design is clearly discernible, and the archaeological evidence identifies that the size of the gun and location on the carriage were marked at the ends of the axles (Figure 7.19). Not all of the axles have the markings, which suggest only one end of the axle was marked with the size of gun and locality on the carriage. With the exception of the markings at the end of the axles there were no other inclusions, such as the recesses, to accommodate the cheeks or bolt and linchpin holes to fasten the components of the carriage. This identifies that there would have been minor differences in sizes and thickness of the various carriage parts, and it was therefore a more sensible practice to make these alterations to the axles specific to the carriage they would be fitted to.

Figure 7.19: Photo of a spare hind axle **Inv18A1448** for a 32-pounder gun carriage (photo by author).

One eroded truck was found outside the coherent port bow between the split with the sections of starboard side structures. During the Bingeman excavations 13 spare trucks were recovered from a location in the forward hold known as Trench B. Bingeman's plan shows Trench B to be at the location of the lightroom and wadding area (Bingeman 2010, pp. 57–8). A diver's measured sketch plan of the trench identifies five trucks, three neatly stacked in what appears to be the corner of the lightroom (Figure 7.20).

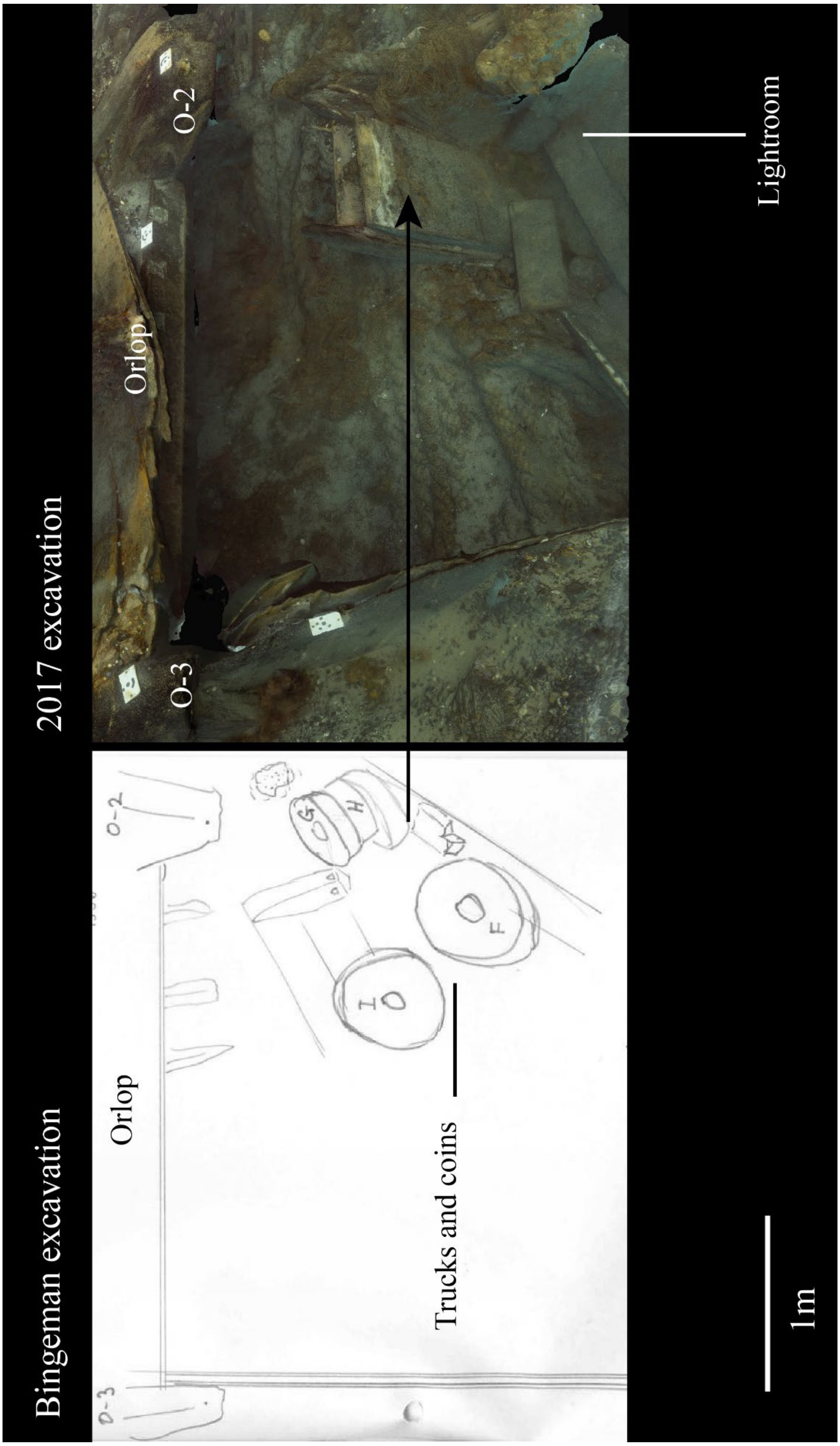

Figure 7.20: Comparison between a divers sketch from the earlier Bingeman excavations and a the 2017 photogrammetry model shows that the trucks and coins recovered during the Bingeman excavations were located at the forward end of the lightroom (Divers sketch courtesy of J. Bingeman, photogrammetry survey conducted by Michael Pitts and figure produced by author).

There were three sizes for the trucks 21, 19 and 16 inch (external diameters) (Bingeman 2010, p. 129). According to the dimensions of ships' carriages from 1748 a 32-pounder gun had 19 inch fore and 16 inch hind trucks; 24-pounders had 18 inch fore and 16 inch hind; and 9-pounders had 16 inch fore and 14 inch hind (Muller 1757, p. 160). Several of the trucks were marked with the calibre of the gun and location on the gun carriage. From the evidence of the marking, the *Invincible's* 32-pounder guns had 19 inch trucks at the front and the 24-pounder guns had 16 inch trucks at the rear. There were no markings on the 21 inch trucks. A possible reason for this was that *Invincible's* gunports were a different size to standard British ports. As a result, the carriages had to be altered so the gun could be located in the correct position through the gunport. One way of altering the position of the gun in relation to the gunport would be to alter the size of the trucks; a larger truck would elevate the position of the gun.

Stool beds and coins

The equipment used to support the breech and elevate the gun were still known as stool beds and coins (Figures 7.18 and 21). According to the list of gunner's stores from this period each gun and carriage was issued with a single stool bed and coin (NMM RUSI/6 and TNAWO55/1745). In addition, there were four spare stool beds and coins for the main and upper deck guns and two spare stool beds and coins for the quarter and poop deck guns (RUSI/6 and TNAWO55/1745). That made 12 spares in total and for the *Invincible:* four spare 32-pounder stool beds and coins; four spare 24-pounder stool beds and coins; and two spare 9-pounder stool beds and coins. The ordnance stores also list 'coins for coining guns of the new pattern' and for a 74-gun warship on foreign duty, '64' were listed. From the archaeological evidence recovered during the current *Invincible* excavations these coins are a different design to the regular coins and will be described below (Figure 7.22).

Figure 7.21: 32-pounder coin recovered from *Invincible* (Photo by author).

Figure 7.22: New type of coin for coining guns of the new pattern recovered from the *Invincible* (Photo by author).

Ten stool beds were recovered from the forward-most area of the orlop during Bingeman's excavation. This was the surviving part of the gunner's store, which would have continued over to the starboard side. Once again, the stool beds are each marked with the calibre of the gun it was intended for; all three calibres are represented. The stool beds are constructed from two pieces of wood, the main part being triangular in shape with a recess cut into the underside at the lower end. This recess is to allow the lower end of the stool bed to slot over the iron through-bolt between the centre of the carriage. Fastened to the underneath of the upper end is a wooden block, which would have rested on the rear axle and elevated the top end of the stool (Figure 7.18). When in use the coin would have laid on top of the stool bed.

Single 32-pounder and 9-pounder coins and several new pattern coins were recovered alongside other gun related equipment from Trench 1 from between the raised floor of the lightroom and main floor of the hold. An explanation for their current location will be discussed in more detail in section 7.4.4.

The design of the 32 and 9-pounder coins are the same. They are wedged-shaped with neat chamfered edges. There are semi-circular finger holes on each side of the coin at the thick end (Figure 7.21), which would have made gripping the coin easier when pulling it from beneath the breech of the gun. There is obviously a considerable size difference between the two coins: the 32-pounder is 690mm long by 280mm wide at the rear end and 172mm at the front end and it is 162mm thick at the rear and 57mm thick at the front; the 9-pounder coin is 544mm long by 200mm wide at the rear end and 130mm at the front and it is 120mm thick at the rear and 36mm at the front. The size of gun each coin was intended for is also clearly marked on the outside face of the wedge (Figure 7.23). A single 32-pounder coin was recovered during the Bingeman excavations, which was marked with *Invincible's* name and the calibre of the gun (Bingeman 2010, p. 131).

Figure 7.23: 32-pounder coin **Inv18A1082** with size inscribed on the rear face (Photo by author).

A total of 14 of the ‘new type’ of coin were found. Eight were found between the raised floor of the lightroom, four were found neatly stacked in the corner of the lightroom and two others were found in Trench 4, within the remains of the starboard side. At least one was recovered during the Bingeman excavations and can be seen in the diver sketch in Figure 7.20. This ‘new type’ of coin is different in design to the regular coins. It is wedged-shaped but with one corner of the thick end cut out. On all but one there are two staggered holes drilled through the broader surface of the wedge. These coins also have neat chamfered edges (Figure 7.22). This type of coin has only been recorded and recovered from one other site, the *St George*, a second rate wrecked in 1811. They are identical in design and were also recovered from the orlop of the *St George*. In both the cases these type of coins came from areas of storage rather than from the carriages on the gundecks, which makes the positioning or attachment of these coins to the carriages currently unclear but hypothesises for their use will be discussed in section 8.4.1 of the next chapter. As all the standard coins are marked with the calibre of the gun, the fact that all the ‘new type’ do not have markings suggest they could be used for all calibres.

7.3.2 *Securing and manoeuvring the guns*

The evidence for securing the guns from the *Invincible* comes from the main gundeck and the concreted remains of ring bolts on either side of the gunports (Figures 7.24 and 25). The clearest evidence survives on the inside of the hull at the location of the aft most gunport on the port side. There was the evidence of two iron ring bolts fastened to the inside of the hull on either side of the gunport. Supporting evidence can be found in the historical record from a letter dated 15th June 1731 from Captain Romney of the 4th-rate *Romney* to Officers at Portsmouth dockyard. The letter stated that the ship had only one pair of ring bolts to each gunport on the lower deck, and that two pairs were required for securing the guns in bad weather and for convenience in time of action (TNA ADM106/830/233).

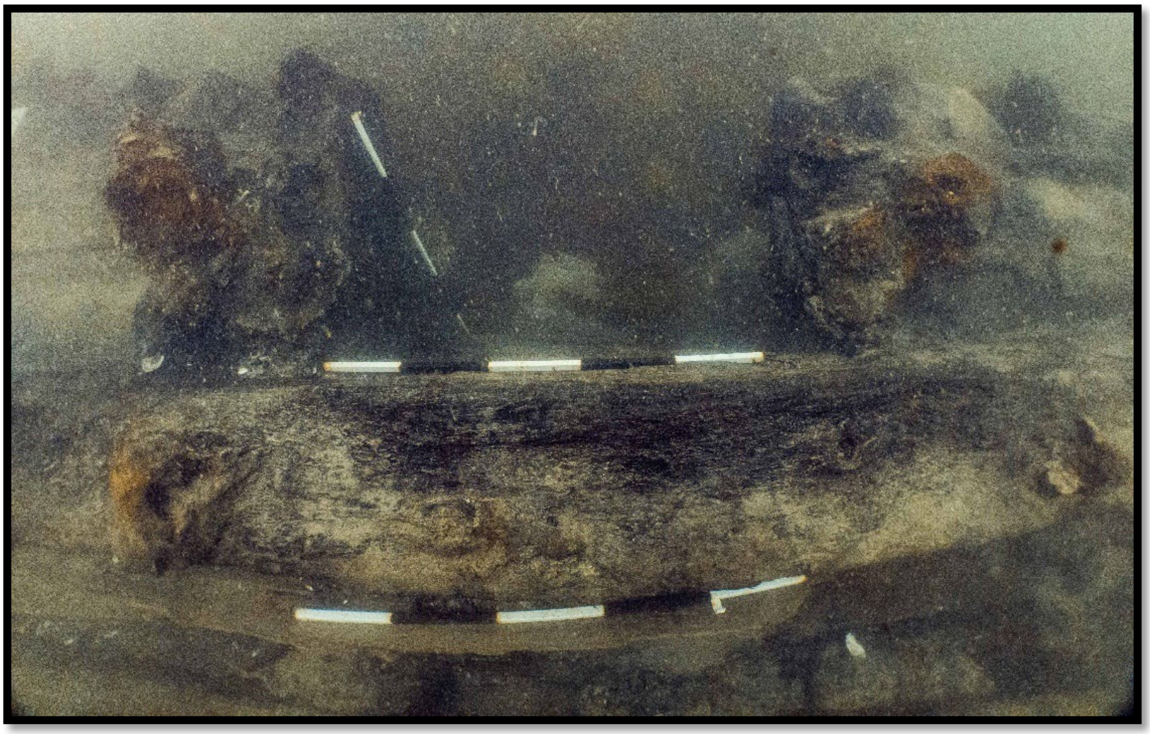

Figure 7.24: Aft most gunport on port side, main gundeck with evidence of ring bolts (Photo by author).

Figure 7.25: The remains of the upper and lower ring bolts on the right side of the gunport (Photo by author).

On each side of the gunport the ring bolts are in a staggered position one above the other (Figures 7.24 and 25). The upper ring bolt is further away from the side of the gunport than the lower. The bottom of the lower concreted ring bolt on the left side of the gunport is 125mm above the sill and the bottom of the lower one on the right side is 105mm above the sill. The bottom of the upper concreted ring bolt on the left side is 316mm above the sill and the bottom of the upper one on the right is 320mm above the sill. Directly above the lower ring bolts on each side was the evidence of another ferrous fastening. These are possibly the remains of eye bolts.

The breeching rope that controlled the recoil of the gun would have been attached to the ring bolts. In the case of the *Invincible* there was the option between a lower and narrower fastening or a higher, wider fastening. It is possible that both ring bolts on each side were used at the same time. During action, having the breeching rope threaded through the lower ring bolt and fastened to the upper ring bolt would have had two effects: first, it would create greater friction when the gun recoiled and, second, the force of the recoil could be shared between four ring bolts, thereby reducing the strain on the side of the hull. During bad weather a greater number of ring bolts would provide an advantage, as it would give more options for lashing the gun securely to the side of the hull. These options can be seen on the present day HMS *Victory* (Figure 7.26). The gun tackle that was used to run the guns out for firing, and which included the double and single blocks, was hooked onto the eye bolts above the ring bolts (Figure 7.26).

Figure 7.26: Double ring bolts on HMS *Victory* (Photo by author).

Gun tackle

To move the guns backwards and forwards gun and train tackle were used (Figure 7.27). Each gun would need two pairs of single and double blocks for the gun tackle and a pair for the train tackle. In addition, 74- gunships like *Invincible* were issued with seven pairs of spare 10 and 8 inch single and double blocks, and seven pairs of spare single 6 ½ inch blocks (NMM RUSI/6). The evidence for these spares comes from single and double blocks found in the remains of the gunner's store on the orlop, in other areas nearby on the orlop and in the hold below. During the current excavations a ten inch single and double block were found lodged under the deck of the orlop in the area of the forepeak. It is highly likely that this pair originated from the gunner's store above.

Figure 7.27: Top left a 10 inch double block, top right a ten inch single block at the centre is a reel of six 9-pounder tampions (Photo by author).

During the Bingeman excavations, 6 single and 9 double 10-inch blocks and one single 8 inch block were recovered from the remains of the gunner's store on the orlop (Figure 7.29). A further 10 single and three double 10-inch blocks, five single and one double 8-inch blocks and four single 6 ½ inch blocks were recovered from other areas nearby in the bow. Between the two eras of excavation that makes a total of 15 single and 16 double 10 inch blocks recovered from or close to the remains of the gunner's store. This is just over the quota issued to a 74 on foreign duty, which was 7 pairs of 10 inch single and double blocks (NMM RUSI/6 and TNA WO55/1745).

Hand crow leavers

To traverse the guns from side to side or to elevate the breech end of the gun, one of the implements used were hand crow leavers/hand spikes. A 74-gun warship during foreign service was issued with 87 6ft long and 24 5ft long (NMM RUSI/6). That was enough for one for each gun and several spares. During action it is highly likely that hand crow leavers from the guns on the side not engaged were used by the crews of the guns in use. The remains of six were recovered from the port bow, one from the area of the gunner's store, four from the area believed to be the sail room—this was immediately aft of the gunner's store—and one was found in the forward section of the hold. The hand crow leavers/hand spikes were in poor condition but, where complete, examples ranged in size from 1810-1640mm and were made of ash (Bingeman 2010, p. 164). They were similar to the examples recovered from the *London* (section 5.3.2) but without the iron shoe.

7.3.3 *Dressing the guns when not in use*

Aprons of lead

According to contemporary inventories a 74-gun warship for foreign service was issued with 92 large and 15 small aprons of lead (NMM RUSI/6 and TNA ADM160/150). During this period there was a record of two distinct sizes and, of the 107 issued, 33 were spares. Logic would suggest the large aprons were for the large calibre guns on the main and upper decks and the small aprons were for the smaller calibre guns on the quarter deck and forecastle. *Invincible* like other 74s was armed with 16 9-pounders on the quarter and forecastle decks, so 15 small aprons appear a strange number to issue these ships.

During the Bingeman excavations a total of six small and eight large aprons were recovered. The small aprons measured 140 x 140mm and the large 254 x 324mm and they had either a single or two pairs of lanyard holes for securing to the gun (Figure 7.28).

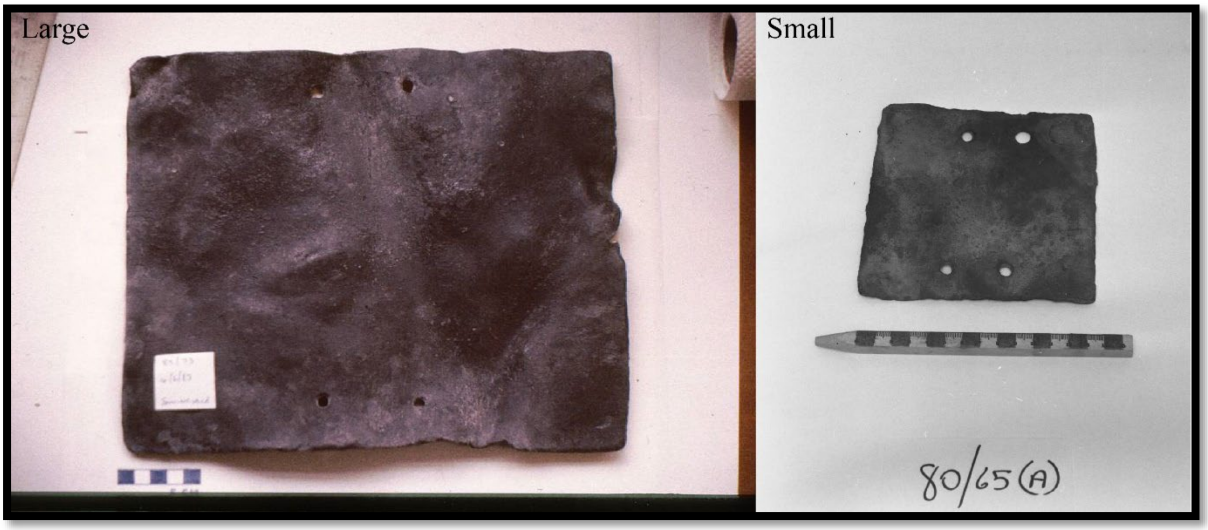

Figure 7.28: Example of a large and small apron from the *Invincible* (Courtesy J. Bingeman).

Tampions

According to contemporary inventories, a 74-gun warship for foreign service was issued with up to 112 tampions for the 32-pounder guns, 120/112 for the 18 or 24-pounder guns and 72 for the 9-pounder guns (NMM RUSI/6 and TNA ADM160/150). The large number of spares indicates they were a consumable piece of equipment. From the archaeological evidence on the *Invincible,* surplus tampions were carried in reels of up to six, much like the example found on the *London* (section 5.3.3), and also in singles. During the Bingeman excavations seven reels of 32-pounder tampions were recovered, one reel of 24-pounder tampions and a single 9-pounder tampion (Bingeman 2010, p. 123). During the 2017 -2019 excavations two reels of 9-pounder (Figure 7.27) and two reels of 32-pounder tampions were recovered. Like the *London* example, and also those found on the *Mary Rose,* they have been turned from a single piece of wood with groves cut to segment the individual tampions.

7.3.4 *Loading and firing equipment*

The evidence for loading equipment from the *Invincible* comes in the form of the spare rammer and sponge heads and wadding, located mainly in two separate stores. The rammers and sponge heads were mainly located in the gunner's store on the orlop with the exception of a few found close by in other areas of the bow. The wadding was found in a space next to the lightroom, immediately below the gunner's store on the orlop (Figure 7.10). The evidence for firing the guns comes from gun flints used with cannon locks, which were being trialled on the *Invincible's* 9-pounder guns, and also slow match, which was the alternative and more traditional method of igniting the guns.

Rammers and sponges

According to the list of gunner's stores a 74-gun ship for foreign service was issued with 14 spare 32 and 24-pounder rammer and sponge heads and nine spare 9-pounder rammer and sponge heads (TNAWO55/1745). During the Bingeman excavations 14 32-pounder rammer heads, 12 24-pounder rammer heads and three 9-pounder rammer heads, seven 32-pounder sponge heads, eight 24-pounder sponge heads and one 9-pounder sponge head were recovered (Bingeman 2010, p. 125). The majority of these came from the remains of the gunner's store on the orlop (Figure 7.29). A 24-pounder rammer head was recovered in 2016 and another during the 2017 excavations. These came from the forepeak directly below the gunner's store on the orlop. All the spare 32 and 24-pounder rammer heads issued to the *Invincible* have therefore been recovered.

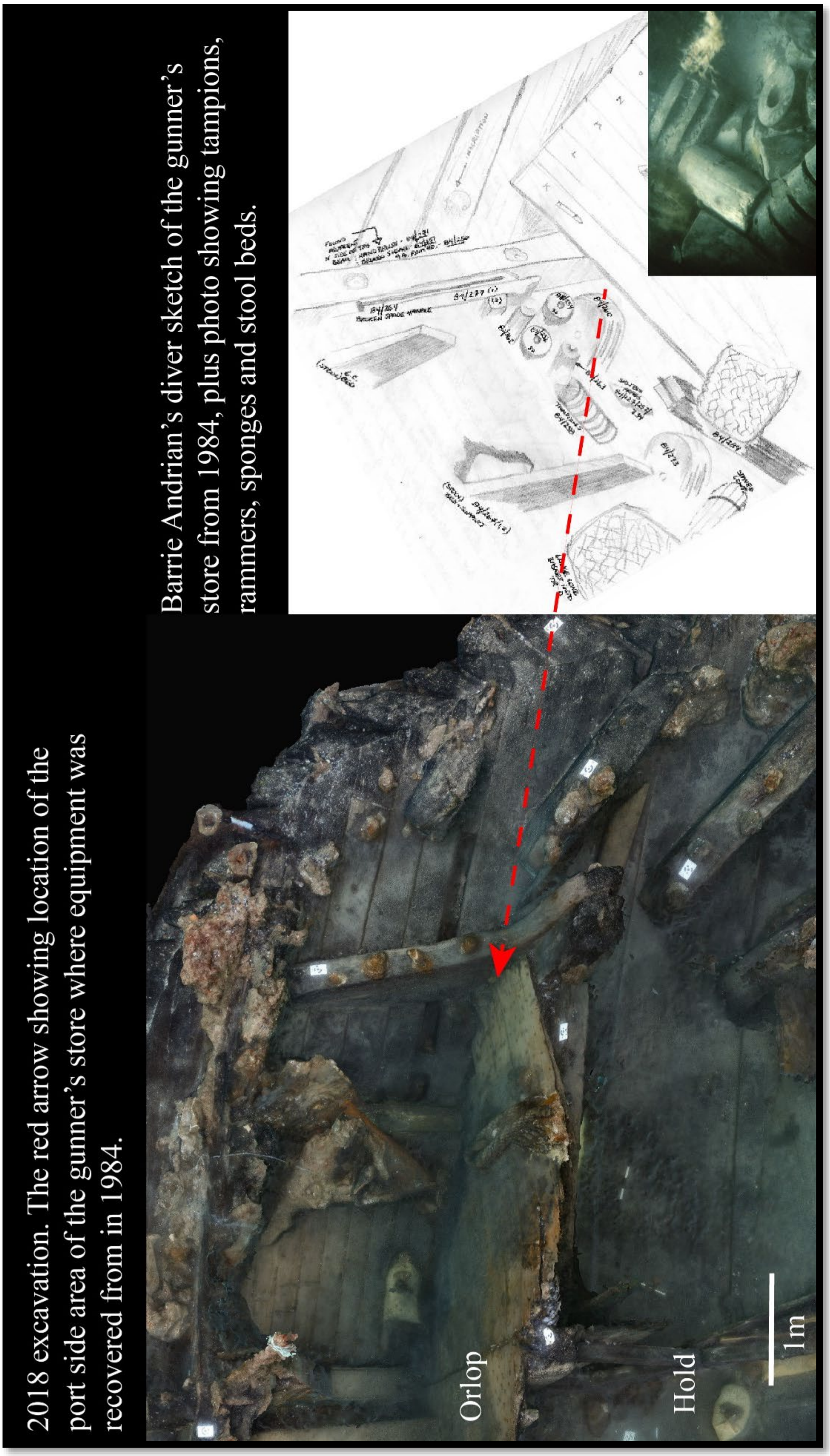

Figure 7.29: This image shows the location of a diver's sketch from the 1984 excavations next to the 2018 photogrammetry model of the port bow. The sketch shows the variety of spare gun equipment found at this location. The equipment included tampions, rammers, sponges, blocks and stool beds (Sketch courtesy of J. Bingeman, figure produced by author).

There were two types of rammer heads, those that had a hole bored all the way through and those that were only partly bored and had a copper band at the top of the neck. The latter went on the end of a solid stave and the former was fastened to the end of a stiffened rope. The rammer heads that were completely bored were the more numerous as the flexible rammer and sponges were issued to every gun and more regularly used. The rammers and sponges on the end of a solid stave, on the other hand, were shared between several guns.

The 32-pounder rammer had a maximum external diameter of 156mm (6.1 inches), the 24-pounder rammer head had a maximum external diameter of 138mm (5.4 inches) and the 9-pounder rammer head had a maximum external diameter of 98mm (3.8 inches). The rammers are clearly marked with the calibre of the gun they were intended for (Figure 7.30). The profile of the rammers were the same for all three sizes. The main body of the rammer tapers inwards slightly from the face to the shoulder. From the top of the shoulder there a recess followed by the neck with a semi-circular moulding (Figure 7.30).

Figure 7.30: A rammer head for a 24-pounder gun (Photos taken by Arantza Novelo and figure produced by author).

All three sizes of sponge cylinders were recovered during the Bingeman excavation, but none were found during the current investigations. A total of 16 sponge heads were recovered, one 9-pounder, eight 24-pounder and seven 32-pounder. Some of the heads were stamped with either 32 or 24 to indicate the calibre of the gun. They are all the same shape: a straight cylinder with a hole running through the centre (Figure 7.31). The 24-pounder head was 225mm long with a diameter of 115mm and the 32-pounder head was 245mm long with a diameter of 125mm.

Figure 7.31: A sponge head recovered during the Bingeman excavations (Courtesy J. Bingeman).

Wadding, gunwads and junk

Just aft of the forepeak there was a compartment between the portside wall of the lightroom and the side of the hull. This area was full of wadding, also known as gunwads. Below the wadding were numerous lengths of junk (Figure 7.10). The wadding are balls of yarn and they were piled up in string bags. Only pieces of the bags survived but these showed that the string was made from three yarns twisted together (Figure 7.32). The bags came with a tally stick providing the calibre of the gun they were intended for, which were made of thin strips of wood with the calibre written in Roman numerals: XXXII for 32-pounder and XXIIII for 24-pounder. The 9-pounder tally sticks were blank, probably because their size is considerably less, whereas the 32 and 24-pounder wads are a similar size (Figure 7.33).

Figure 7.32: Gunwad **Inv17 0230** with fragments of the string bag (Photo by author).

Figure 7.33. Examples of the three sizes of wadding with their associated tally stick indicating the calibre of the gun (Photo by author).

The wadding was made by picking the yarn from the junk and wrapping it into a ball to fit the bore of a gun. Dissection of a sample of the wadding has identified two ways in which the process of making the wad was started: one method was to scrunch up a ball of vegetation to aid the start of the wrapping of the yarn, the other was without. The former suggesting that this type was made ashore rather than on the ship. The core of the wad was bound and finished by a network of horizontal, vertical and diagonal wraps, with a final flourish of a zig zag of a single yarn going around the horizontal wrapping (Figures 7.32-33). Making these wads would have taken significant skill and therefore considerable time and effort.

There was one exception with the make-up and construction of the wad. Wad **Inv17 0517** was made with a core of sennit, which was bound in the typical manner with a wrapping of yarns (Figure 7.34). Sennit is a flat cordage made by plaiting five or seven yarns together

(Smyth 2005, p. 607). The use of the sennit seems to be rather makeshift and is possibly an example of a wad made in haste, on board ship.

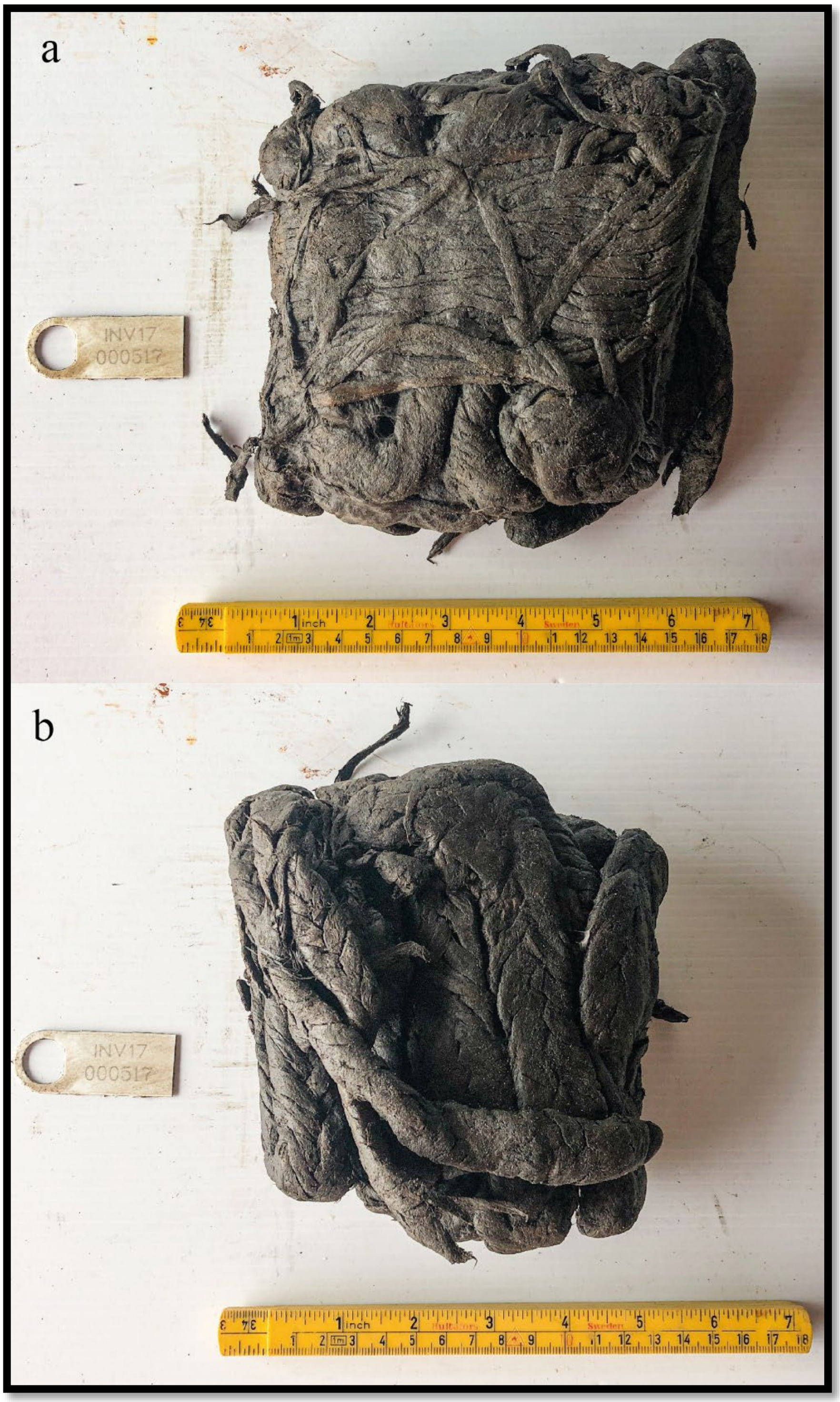

Figure 7.34: Gunwad **Inv17 0517** constructed in part from sennit. Image **a** showing the sennet core has been wrapped in the typical fashion. Image **b** shows the core of sennit (Photos by author).

During the Bingeman excavations 14 gun wads were recovered (Bingeman 2010, p. 115), with approximately 1000 recovered during the current excavations. Below and around the outside of the wadding was the junk, some of which was also coming from the forepeak. The junk was made up of various sizes of cable-laid rope and hawser-laid rope. It also included large pieces of served cable laid rope (Figure 7.35). Seventy-four gunships during this period were issued with nearly seven ton of junk for foreign service (TNA WO55/1745). This junk was included in the gunner's stores and was used to make wadding.

Figure 7.35: Examples of the various sizes of cable laid rope recovered from the junk and wadding store (Photo by author).

Slow-match and cannon locks

Once a gun was loaded with the powder charge, wads and shot, it would then be primed and run out through the gunport. The standard method for firing the gun at this time was still for the gun captain to ignite the priming powder in the touch hole at the breech end of the gun using a slow-match. The slow-match was traditionally threaded through the end of a linstock as described in chapter five on the *London*. The linstock enabled the gun captain to stand at a safe distance from the recoiling gun. The ordnance stores, however, from at least 1716 onwards no longer include linstocks but instead list the match only, in quantities of quarters of hundred weight (qrs,cwt) (TNA WO55/1739 and NMM RUSI/6). According to Lavery, by the 1760s linstocks were only used on small warships (Lavery 1984, p. 143). Considering the fragile structure of slow-match a remarkably well-preserved example of it was found on the wreck during the 1980s excavations. A 14-foot length of slow-match was found neatly coiled in a circular pouch made of fearnought cloth. Fearnought is a tightly woven and shrunken cloth used by the Royal Navy for heat protection (Bingeman 2010, p. 121) The end of the slow match, which exited the pouch, was pulled from the centre of the coil (Figure 7.36). Bingeman suggests it was used by marines to ignite hand grenades (Bingeman 2010, p. 121) but with the redundancy of the linstock the slow-match pouch could also be a transition between the linstock and the cannon lock. The slow-match pouch enabling a more controlled method of igniting the gun on a moving ship but increasing the risk of injury to the user during the recoil of the gun.

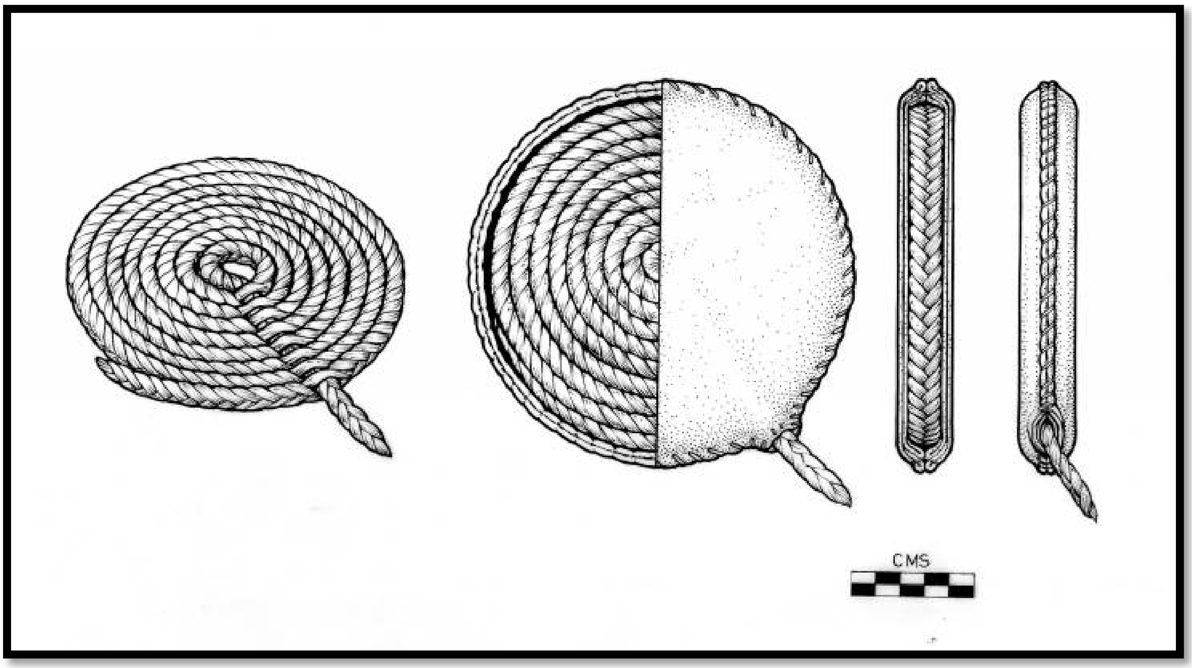

Figure 7.36: Drawing of the slow match pouch recovered from *Invincible* (Drawing by N. Lacey and courtesy of J. Bingeman).

The *Invincible*, in fact, was also trialling the new firing mechanism, the cannon lock. These locks were trialled on the 9-pounder guns only (TNA ADM2/219); the 32 and 24-pounders were still fired using the traditional method of using a slow-match. The new gun locks were attached onto a raised section at the vent hole of the gun (Figure 7.37). Accompanying the new gun lock was also a new method of priming the gun, which involved a tube prefilled with priming powder that was inserted down the vent hole. The cannon locks worked much in the same way as a musket lock, in that a flint was attached to a cocking handle that, when triggered, struck against a striking plate. This then produced a spark, which ignited the priming powder in the pan of the lock. This in turn ignited the powder in a priming tube, which had been inserted down the touch hole.

Figure 7.37: A 9-pounder Armstrong pattern gun with raised touch hole and fixing holes for the attachment of a gun lock. This is the same type of gun the *Invincible* was issued in 1755 on her quarter deck (Photo by author).

The evidence of this new technology on *Invincible* survives in the form of gun flints only. Hundreds of flints have been recovered from the site during both phases of excavation (Figure 7.38). The flints have all been found in the vicinity of the port side bow and therefore close to the location of the gunner's store. The flints have been carefully knapped into a wedge shape with a thin and sharp striking edge along one side. Not all the flints would have been for use with the 9-pounder guns. *Invincible* was issued with hand weapons, such as pistols and muskets, which were fitted with flint lock firing mechanisms. However, five distinct sizes of flints have been recovered and it is possible that the larger sizes were for use with 9-pounder gun locks.

Figure 7.38: A selection of gun flints (Photo by author).

7.3.5 *Unloading*

Ladles

A 74-gun ship would have been issued with ten ladles in total, four each for the 32 and 24-pounder guns and two for the 9-pounder guns (TNA WO55/1745). One ladle, **Inv19 3193,** was recovered from Trench 4 in 2019. It is a composite object consisting of a wooden body, similar in design to a rammer head but with a copper scoop attached around the body of the head (Figure 7.39). The diameter of the wooden head is 156mm (6.1in) and the diameter of the copper scoop is 162mm (6.4in). The copper is badly corroded and, as a result, has laminated making the size of its diameter inaccurate. The size of the wooden head is a more reliable measurement and would make the ladle appropriate for the 32-pounder guns.

Ever since powder charges were placed into cartridges the use of the ladle for loading became obsolete as the charge could be easily handled and placed into the barrel of the gun and pushed down by the rammer. The inclusion of ladles in the inventories show they still had a use but instead of loading they were used to extract the load if the gun was not intended to be fired (Povey 1702, p. 30).

Figure 7.39: The partial remains of a ladle (**Inv19 3193**) for a 32-pounder gun (Photo by author).

7.4 Evidence for the supply, organisation of the gunnery system

For an efficient and effective naval gunnery system on board, the supply chain of powder charges, wads, shot and spare equipment has to be organised, well maintained and, when needed, in constant supply. A Royal Navy warship needed to be ready for action, guns loaded and an immediate supply of powder charges, shot and wadding for a sustained period of action from the moment the ship leaves port. The responsibility of having the ship ready for action was ultimately shared between the Captain and the Master Gunner. The Master Gunner was responsible for all the stores and equipment for working and maintaining the guns, as soon as he signed for it on delivery from the Ordnance Gunwharf (Cole 2009b, p. 286). He was responsible for having enough shot, powder charges and wadding for all calibre of guns ready for a sustained period of action. Historical evidence from the accounts of ship's Captains during the Napoleonic wars show that they liked to have enough ammunition, charges and wads ready for one hour's action (Cole 2009b, p. 287). If the rate of fire was one shot every five minutes and a 74-gunship engages an enemy on one side for 1 hour, it would potentially need 444 shot and charges and 888 wads. The archaeological evidence recovered and recorded from *Invincible* will reveal the level of this type of organisation on the ship.

Although the great guns from *Invincible* were salvaged at the time of the wrecking, evidence from other wreck sites have identified that the guns were loaded even when the ship was not in battle. Evidence of this comes from the excavation of gun barrels from the wreck of *Victory* 1744. *Victory* was lost during a storm in 1744 and the wreck was discovered in the early 2000s. Three bronze guns, a 40, 24 and 12-pounder were recovered from the wreck. Excavation of the barrels showed they were loaded with a single charge, a round shot with wadding and tampion in place (Kingsley 2018, p. 93). This wasn't a new practice as the same evidence has been identified from earlier wrecks, such as the *Stirling Castle* (1703) (McElvogue 2008, p. 41).

On its final commission, the *Invincible* was embarking on a mission across the Atlantic, but would be entering hostile waters of the English Channel from the moment it left the shelter of the Isle of Wight; there is little doubt that the guns would have been loaded when the ship ran aground. In fact, shortly after the ship went aground on the 19th February, Captain Bentley writes in his log that the guns were fired at different times as a distress call (TNA ADM 51/471); the guns were clearly loaded and fired several times. Determining whether the

Invincible was prepared for a sustained period of fighting is more challenging. However, the high level of survival and preservation of both structures and objects provides the greatest opportunity to do this for a ship of the line from the mid-eighteenth century.

7.4.1 *Shot*

Supply of Shot

The inventories identify that the *Invincible* was supplied with three types of shot: round shot, grape shot and double headed shot, available for the three calibres of great guns. The round shot was the most abundant: according to the gunner's store list of 1763 the 32-pounder guns on a 74-gun warship during foreign service for example would have a supply of 2240 round shot, 140 grape shot complete and 84 double headed hammered shot (TNAWO55/1745). This shows other types such as bars of iron and case or canister shot were no longer in use. The fewer types of shot would have made supply and organisation on board much simpler. It also shows that the navy had realised which types were the most effective. The introduction of grapeshot at the beginning of the century probably leads to the redundancy of earlier types, such as the base and bur, case and canister shot.

Organisation

A small amount of shot would have been kept on shot racks along the sides of the gundecks between the gunports (Lavery 1987, p. 150) and, while the archaeological evidence for this does not survive on the *Invincible,* evidence from the later *St George* will be discussed in the next chapter. The majority of the shot was stored in shot lockers. Ship's plans and the archaeological evidence from the *Invincible* show the shot lockers were located immediately fore and aft of the main mast, to maintain the stability of the ship. The shot lockers were divided vertically into several sections to accommodate the different types and calibres of shot (Lavery 1987, p. 150).

In the case of the *Invincible* the excavation of Trench 2 exposed an area 10m fore and aft by 7m across of round shot, and it was even possible to identify forward and aft concentrations. These concentrations represented two shot lockers in front of and behind the location of the main mast. (Figure 7.40). The forward concentration of shot (3m by 7m) was concreted together as one mass but appeared to be all round shot. It was mainly contained fore and aft between two riders and along the sides by the upward rise of the floor (Figure 7.40). Riders are large reinforcing timbers that run transversely across the inner hull above the ceiling planks; they stiffen and strengthen the hull. The depth of the riders were 0.44m and the depth of shot was one layer above the height of the riders. There was no evidence surviving of the actual sides of a shot locker.

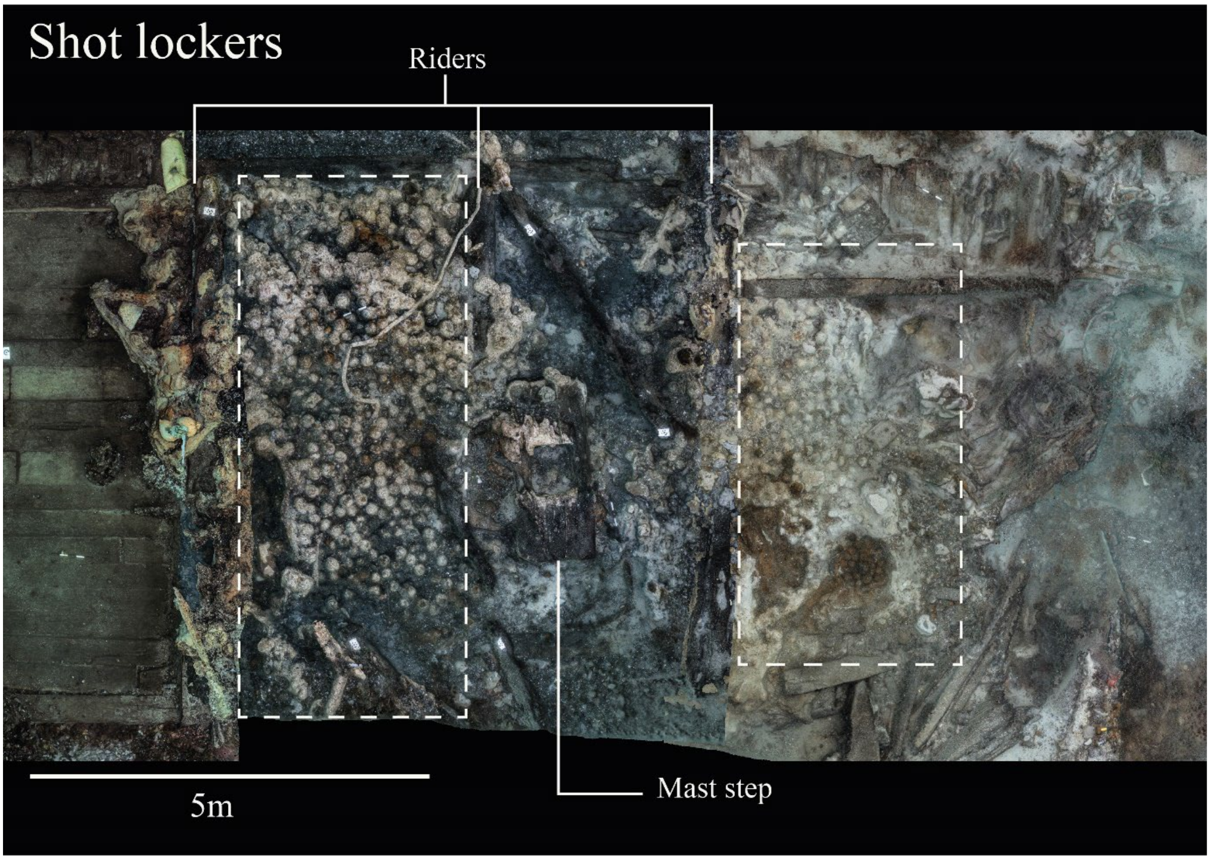

Figure 7.40: A close-up of the forward shot locker (Survey conducted and model produced by author).

The aft area of shot was smaller (3m by 5.5m) and only contained at the forward end by a rider; the aft rider was missing. All the shot in this area also appeared to be round shot. A total of 18 shot were recovered from here, nine 9-pounder and nine 24-pounder. However, among the shot were at least six cast iron swivel guns, of which five were recovered. During the process of excavating the swivel guns from the concreted shot, several shot were excavated and removed. These shot, along with a sample of shot from the forward area, were all found to be either 9 or 24-pounder round shot. Assessment of the entire surface of the exposed shot concluded that there was no other type of shot visible. During the Bingeman excavations a total of 101 individual grape shot were recovered from the surviving area of the gunner's store or areas immediately adjacent to it (the number and locations came from J. Bingeman's artefact database) (Bingeman 2017, p. 163). This demonstrates that at least some of the ship's grape shot that was not intended for immediate use and was stored in the gunner's store.

Bentley's log reveals that on the 22nd February, the fourth day since the wrecking, along with the guns a 'hoy load of shot and gunner's stores' was got out (TNA ADM51/471). It is possible to deduce from this and the archaeological record that the surplus double headed shot was stored in the upper sections of the shot lockers, which remained above the water long enough for this shot to be removed. The double headed shot and the grape shot were designed for specific targets such as masts, rigging and personnel. It would therefore have been beneficial to have these in separate compartments near the top for ease of access or, with the case of the grape, stored separately in the gunner's store where it was unlikely to be damaged by the heavier and more robust round and double headed shot. It is also possible that the 32-pounder round shot was removed but it is more likely that the heavier 32-pound shot was stored below the 9 and 24-pounder round shot for stability, and is now obscured by the remains of the 9 and 24-pounder round shot. One 32-pounder shot was found and recovered from the remains of the main gundeck demonstrating that not all the shot on the main gundeck was salvaged.

Manufacture of shot

A sample of 19 round shot were recovered from Trench 2, nine 9-pounder and nine 24-pounder shot from the area of the shot lockers, amidships and one 32-pounder shot from the main gundeck. The 9-pounder shot recovered ranged in diameter from 99-110mm (3.89-4.33in) but with five of the nine measuring 102mm (4.01in). The bore of an English 9-pounder was 107mm (4.21in) and the appropriate diameter of shot for that calibre was 101.6mm (4in) (Table 7.1). The 24-pounder shot recovered ranged in diameter from 139-143mm (5.47-5.62in). The bore of an English 24-pounder was 148mm (5.84in) and the appropriate diameter of the shot for that calibre was 140.7mm (5.54in) (Table 7.1). The 32-pounder shot recovered was 152mm (5.98in). The bore of an English 32-pounder was 163mm (6.42in) and the appropriate diameter of the shot for that calibre was 155mm (6.1in) (Table 7.1). The slight variations in the sizes of the shot of the same calibre show that the casting of round shot did not result in supplies of identically cast or precise shot and occasionally shot were produced over sized, as demonstrated by the 9-pounder shot **Inv17 1883.** This shows the importance of carrying shot gauges to ensure that any oversized shot was discovered before it made its way up onto the gundecks.

Artefact Number	Calibre of gun	Bore mm (inch)	Shot mm (inch)	Recovered Shot mm (inch)	Weight kg (lbs oz)
Inv17 1883	9-pounder	107mm (4.21in)	101.6mm (4in)	110mm (4.33in)	4.058kg (8lb 15oz
Inv17 1884	9-pounder	107mm (4.21in)	101.6mm (4in)	102mm (4.01in)	3.414kg (7lb 8oz)
Inv17 1885	9-pounder	107mm (4.21in)	101.6mm (4in)	99mm (3.89in)	3.908kg (8lb 9oz)
Inv17 1886	9-pounder	107mm (4.21in)	101.6mm (4in)	99mm (3.89in)	3.406kg (7lb 8oz)
Inv17 1887	9-pounder	107mm (4.21in)	101.6mm (4in)	102mm (4.01in)	3.778kg (8lb 5oz)
Inv17 1908	9-pounder	107mm (4.21in)	101.6mm (4in)	104mm (4.09in)	3.796kg (8lb 5oz)
Inv17 1910	9-pounder	107mm (4.21in)	101.6mm (4in)	102mm (4.01in)	3.902 kg (8lb 9oz)
Inv17 1911	9-pounder	107mm (4.21in)	101.6mm (4in)	102mm (4.01in)	3.914kg (8lb 10oz)
Inv19 3262	9-pounder	107mm (4.21in)	101.6mm (4in)	102mm (4.01in)	3.932kg (8lb 10oz)
Inv17 1063	24-pounder	148mm (5.84in)	140.7mm (5.54in)	141mm (5.55in)	8.698kg (19lb 2oz)
Inv17 1065	24-pounder	148mm (5.84)	140.7mm (5.54in)	141mm (5.55in)	9.082kg (20lbs)
Inv17 1757	24-pounder	148mm (5.84in)	140.7mm (5.54in)	140mm (5.51in)	9.276kg (20lb 7oz)
Inv17 1758	24-pounder	148mm (5.84in)	140.7mm (5.54in)	140mm (5.51in)	10.42kg (22lb 15oz)
Inv17 1759	24-pounder	148mm (5.84in)	140.7mm (5.54in)	143mm (5.62in)	10.356kg 22lb 13oz)
Inv17 1760	24-pounder	148mm (5.84in)	140.7mm (5.54in)	142mm (5.59in)	9.8kg (21lb 9oz)
Inv17 1761	24-pounder	148mm (5.84in)	140.7mm (5.54in)	140mm (5.51in)	9.618kg (21lb 3oz)
Inv17 1762	24-pounder	148mm (51.84in)	140.7mm (5.54in)	141mm (5.55in)	9.444kg (20lb 13oz)
Inv17 1888	24-pounder	148mm (51.84in)	140.7mm (5.54in)	139mm (5.47in)	9.316kg (20lb 8oz)
Inv19 3261	32-pounder	163mm (6.42in)	155mm (6.1in)	152mm (5.98in)	8.516kg (18lb 12oz)

Table 7.1: Table showing the sizes and weights of shot recovered from the wreck of *Invincible* alongside the dimensions of the bore from the calibre of guns aboard the ship. Contemporary dimensions of bores and shot were taken from Caruana (Caruana 1997, p. 112)

The shot were cast in bipartite moulds and in most cases the casting lines are located equatorially with the casting sprue at the polar region. One of the 19 shot, however, had the casting line dissecting the sprue (Figure 7.41), which identifies two types of bipartite mould.

The casting lines were generally smooth and some cases extremely faint suggesting a finely aligning mould. The size of the sprues were generally smaller than the ones recorded on the *Hazardous* shot and they did not exhibit the surrounding depression, which caused a significant flat spot across the circumference of the shot. For the *Invincible* shot this suggest a more controlled pour of the molten iron into the mould. Five of the shot featured makers or crown property marks in the form of a squat arrow impressed or hammered into the surface of the shot between the sprue and the casting line after it was cast (Figure 7.42). It cannot be ruled out that the makers mark was part of the mould but for it to leave an impression in the shot it would have had to have protruded out from the inside surface of the mould.

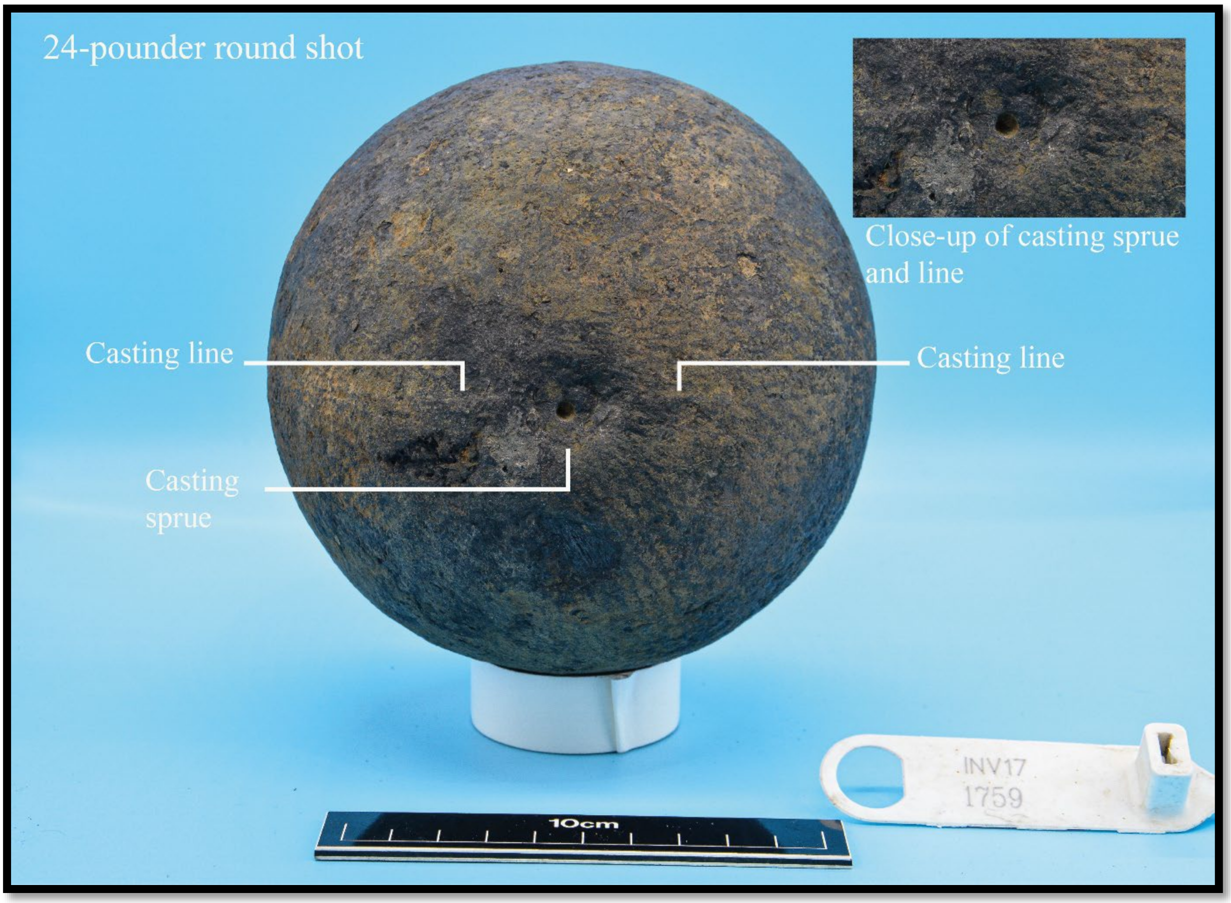

Figure 7.41: A 24-pounder shot showing a very fine casting line dissecting the casting sprue (Photo by author).

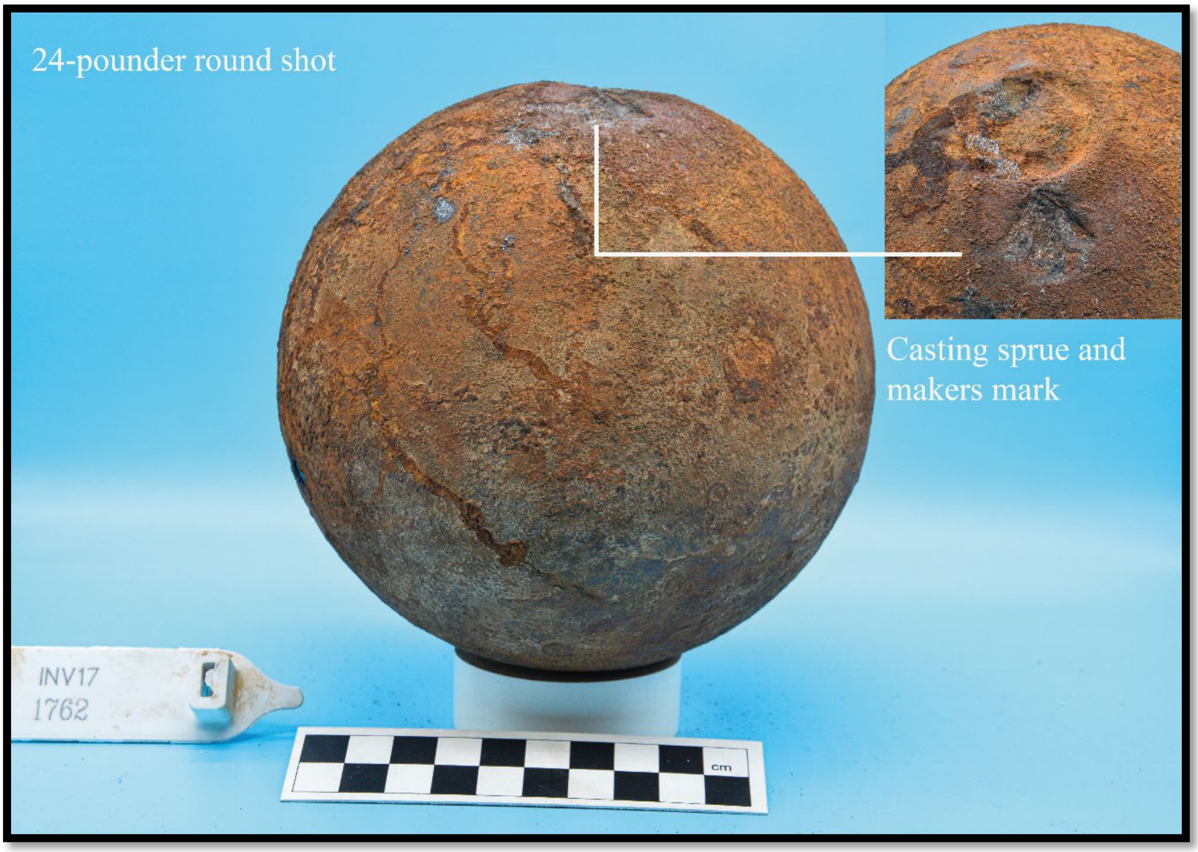

Figure 7.42: 24-pounder round shot showing location of casting sprue and maker mark, the casting line is not visible on this shot but may appear following further cleaning during the conservation process (Photo by author).

Two of the shot featured a small lead plug besides the sprue demonstrating that the same technique for filling cavities left after casting seen on the *Hazardous*, was still being used 50 years later (Figure 7.43).

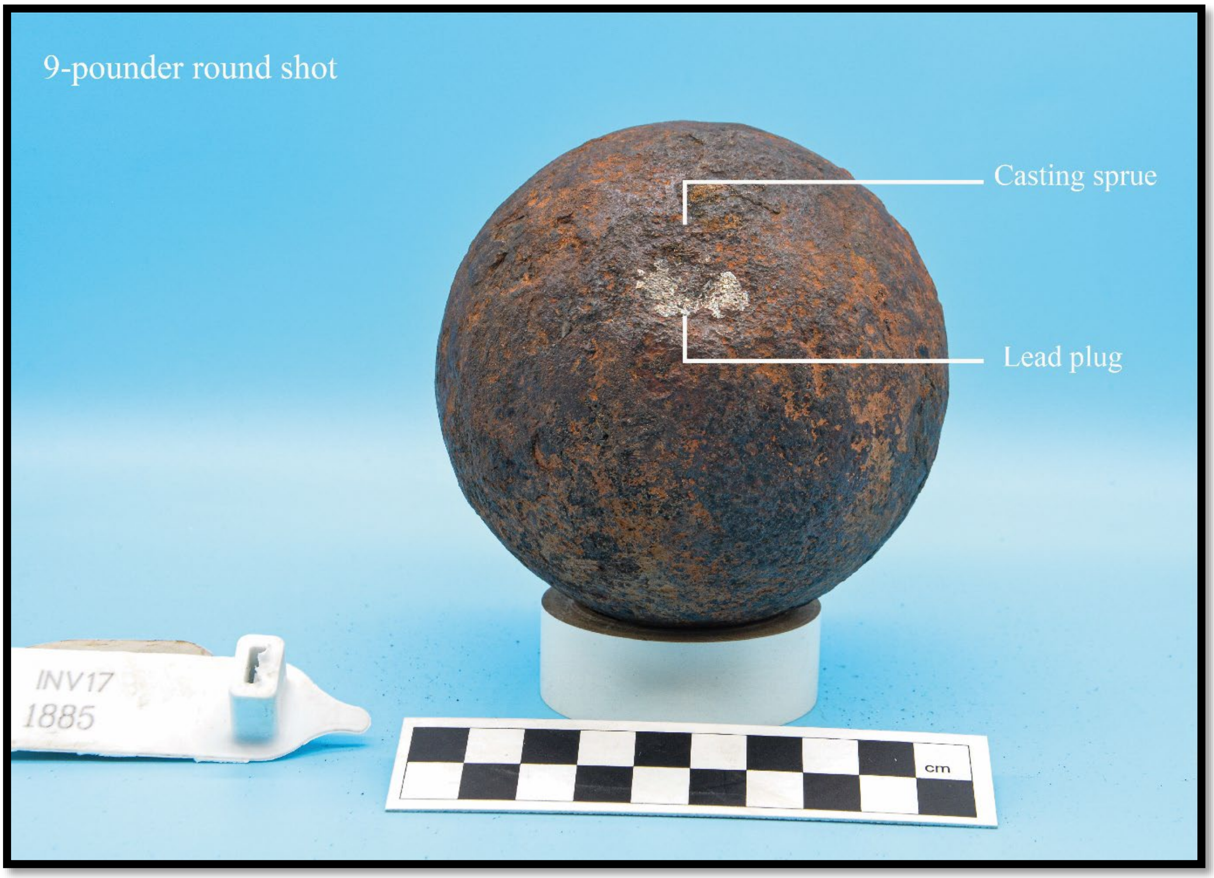

Figure 7.43: A 9-pounder shot with lead plug besides the casting sprue (Photo by author).

7.4.2 *Powder*

Supply

According to contemporary inventories 74-gun warships were issued with up to 398 barrels of powder for foreign service (TNA WO55/1745).

Organisation

The bulk of the powder was stored in the main magazine at the forward end of the hold (Figure 7.44) A smaller magazine was located near the stern end of the ship but no evidence of powder barrels or the internal structure of this magazine were found. This suggests it was either salvaged at the time or has been lost during the wrecking process.

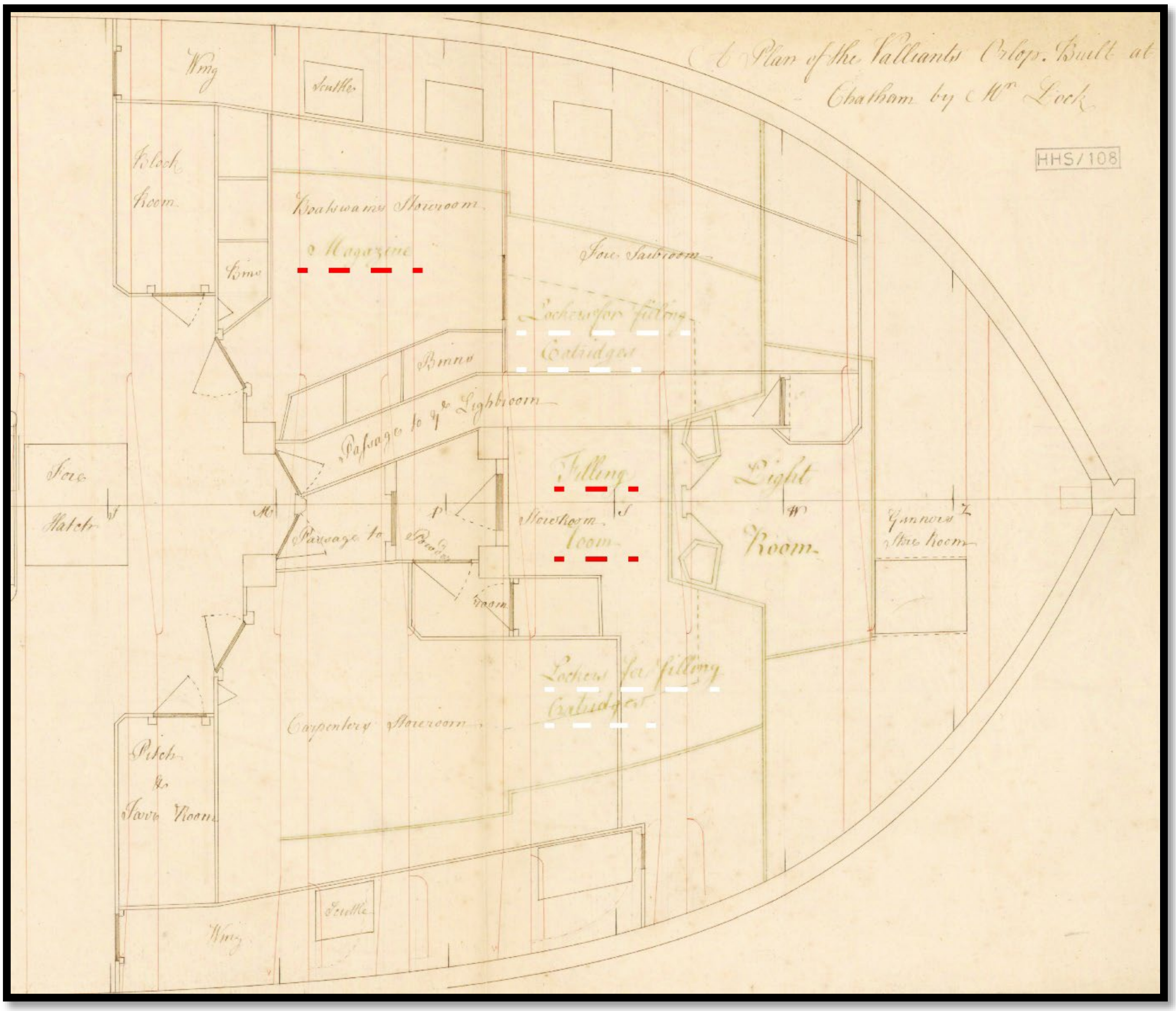

Figure 7.44: The orlop deck plan of the *Valiant* with key areas in the hold also labelled. The red dashed lines highlight the location of the filling room and forward magazine. The white dashed lines highlight the areas for storing cartridges (J8138 courtesy of the NMM).

The wreck of *Invincible* has yielded the most comprehensive archaeological evidence for the storage of powder and powder charges for the great guns for any Royal Navy ship of the line post *Mary Rose*. The main magazine and the section forward of it, known as the filling room (Figure 7.44), were first excavated during the Bingeman excavations in 1980s. This resulted in 48 barrels of powder being recovered from the magazine and, also, the actual structural compartment and contents of the filling room (Figures 7.45 and 46) (Bingeman 2010, pp. 134–136). The powder barrels were constructed of wooden staves and lids secured tight with a combination of several hazel and four copper bands (Figure 7.45). The barrels were 501mm tall and with lids of 365mm diametre.

Figure 7.45: Photos of the gunpowder barrels recovered from the *Invincible* (Courtesy J. Bingeman).

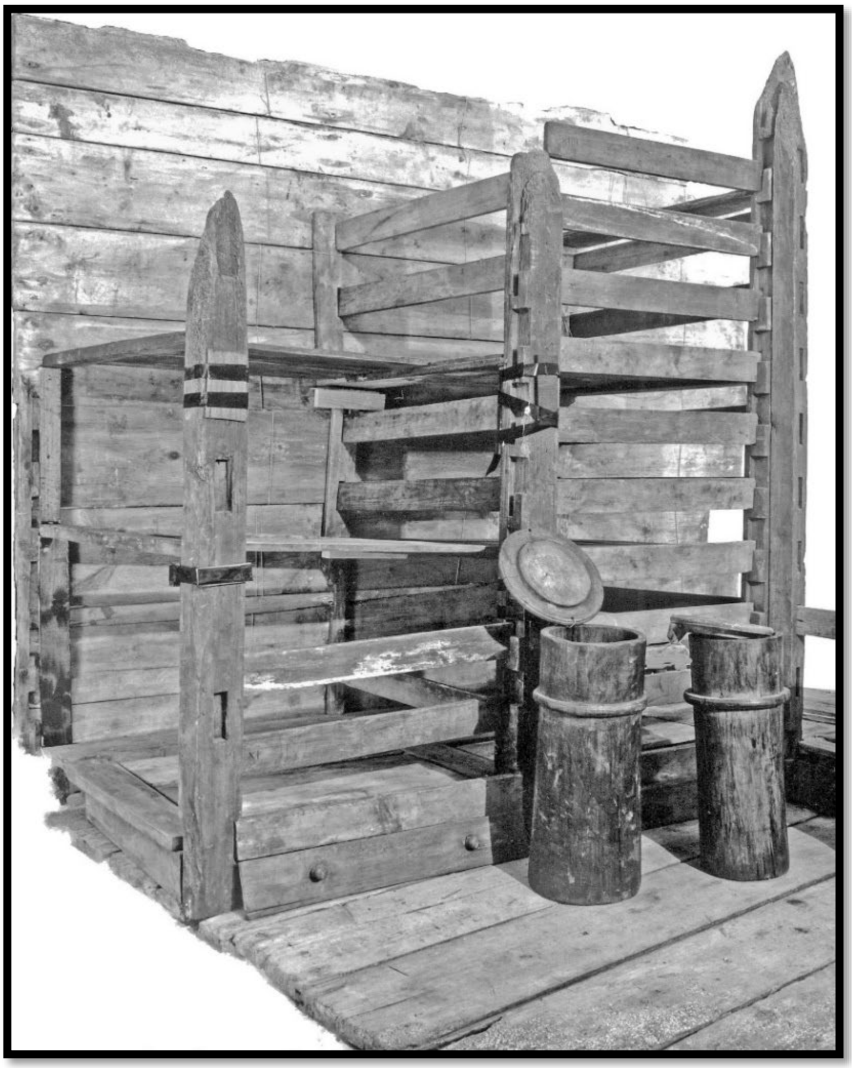

Figure 7.46: The remains of the filling room which was recovered during the Bingeman excavations (Courtesy of J. Bingeman).

The current excavations photogrammetrically recorded the inside of the hull of the empty magazine and the section where the recovered filling room was originally located (Figure 7.47). During the current excavation other complete powder barrels were located in a space that would have been below the internal floor of the filling room. Other complete barrels and many loose staves, lids and copper banding were also found outside the break in the hull, adjacent to the magazine and filling room. These probably originated from the starboard side of the magazine that broke away with the starboard side of the hull.

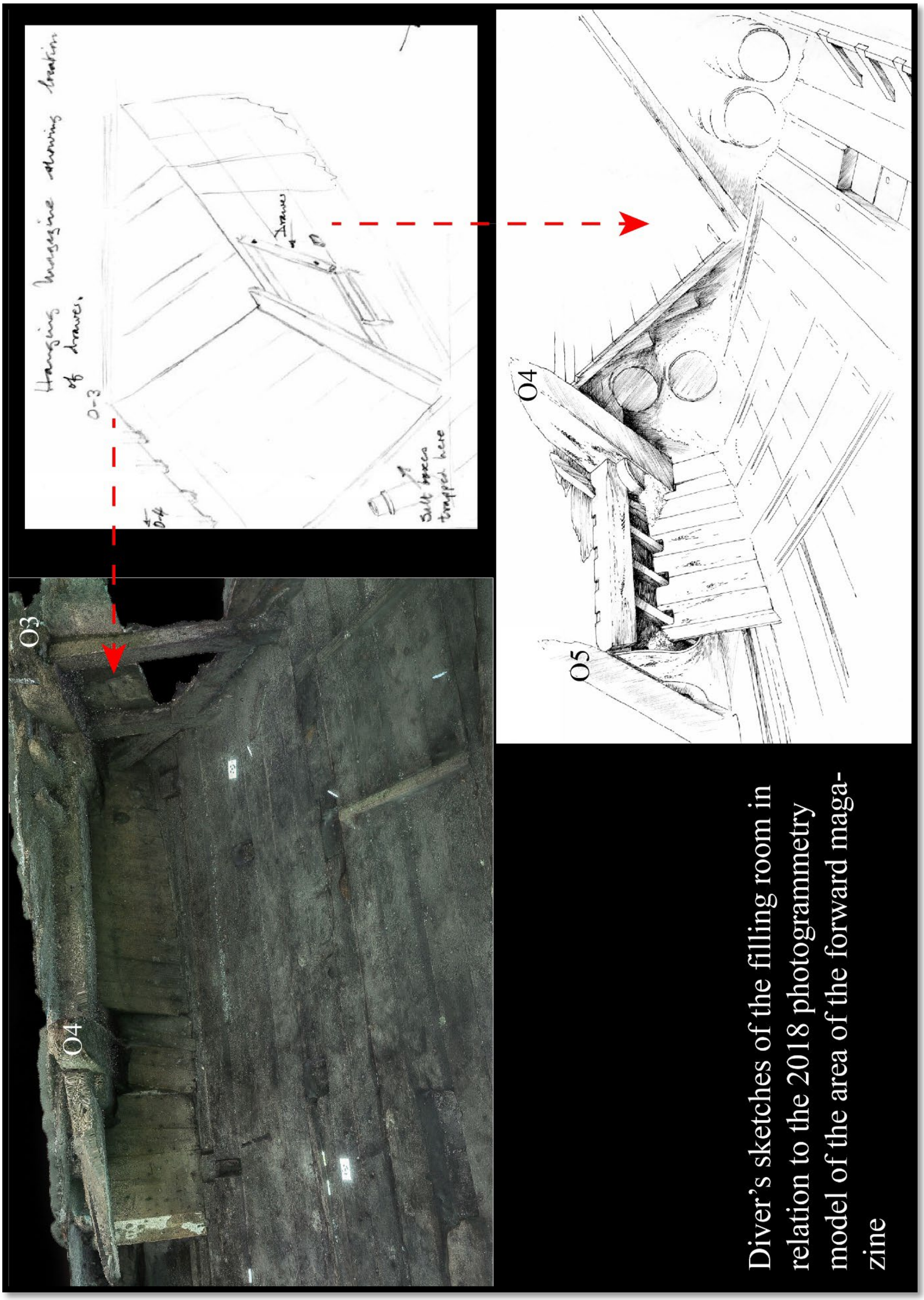

Figure 7.47: Sketches by J. Adams and J. Bingeman of the structures of the filling room in relation to the 2018 photogrammetry survey of the area of the forward magazine and filling room (Sketches courtesy of J. Bingeman, photogrammetry survey and figure produced by author).

The archaeological evidence recorded by Bingeman showed that the filling room was forward of the main storage area of the powder barrels and was raised above the actual floor of the ship and set back from the sides. The separation from the floor and side of the hold would have ensured this area remained dry, but also help contain any powder dust that may have been created when transferring powder from barrels into cartridges. The space between the side of the hold and the side of the filling room, and the space between the floor of the hold and the floor of the filling room, was filled with powder barrels (Figure 7.47). The archaeological evidence from here and other locations on the *Invincible* are demonstrating that any spare or redundant space was utilised.

The recovered filling room was an internal room constructed from plank boarding on the sides and floor that was flush rather than overlapping. Within this structure was wooden racking for storing the powder charges and wooden cartridge cases. The racking was shaped into an L-shaped structure constructed with a network of slotted vertical beams and thin horizontal battens. Four individual bays survived and at the bottom of each bay was a pull draw. These bays were used to store the powder charges (Figures 7.46 and 47) (Bingeman 2010, p. 110).

To transport the powder charges to the gundecks they were placed into wooden cartridge cases, which held a single charge. There were three sizes of cartridge case representing the three calibre of guns. These cases were still referred to as cases of wood in the inventories and the *Invincible* would have been issued with 70 for the 32-pounders, 75 for the 24-pounders and 45 for the 9-pounders (TNA ADM160/150). Over fifty were recovered during the earlier excavations and two complete and several partial ones were recovered during the current excavations. The recent cartridge cases were located between the internal floor timbers beneath the remains of the lightroom, which was immediately forward of the filling room. They were found along with several coins. This position was mostly likely due to the breakup of the ship and subsequent movement of the objects. Many of the cartridge cases during the Bingeman excavations were found just outside the entrance to the filling room in the space between the inside of the hull and the side of the filling room (7.47). The bodies of the cartridge cases were lathe-turned from a single piece of poplar and the cases fitted with a lid. On both the lid and a rim on the case a pair of parallel holes were drilled, through which a thin rope lanyard was threaded to keep the lid and the case together (Figure 7.48).

Figure 7.48: A 9-pounder cartridge case with lid alongside a 32-pounder cartridge case (Photo by author).

As well as the cartridge cases a single powder box with two copper powder measures inside was also found in this room. The purpose of the box was to decant powder into from the barrels, with the measures used to put a single charge of powder into a paper cartridge (Figure 7.49). The box was constructed from soft wood (pine planks) and secured using tenon and mortise joints. The box tapers up from the bottom with the base being 760mm by 46mm with a depth of 36mm. The handles of the box were fastened to the sides of the box using small wooden treenails. Iron nails were avoided to negate the possibility of creating a spark that could ignite the powder (Bingeman 2010, p. 106).

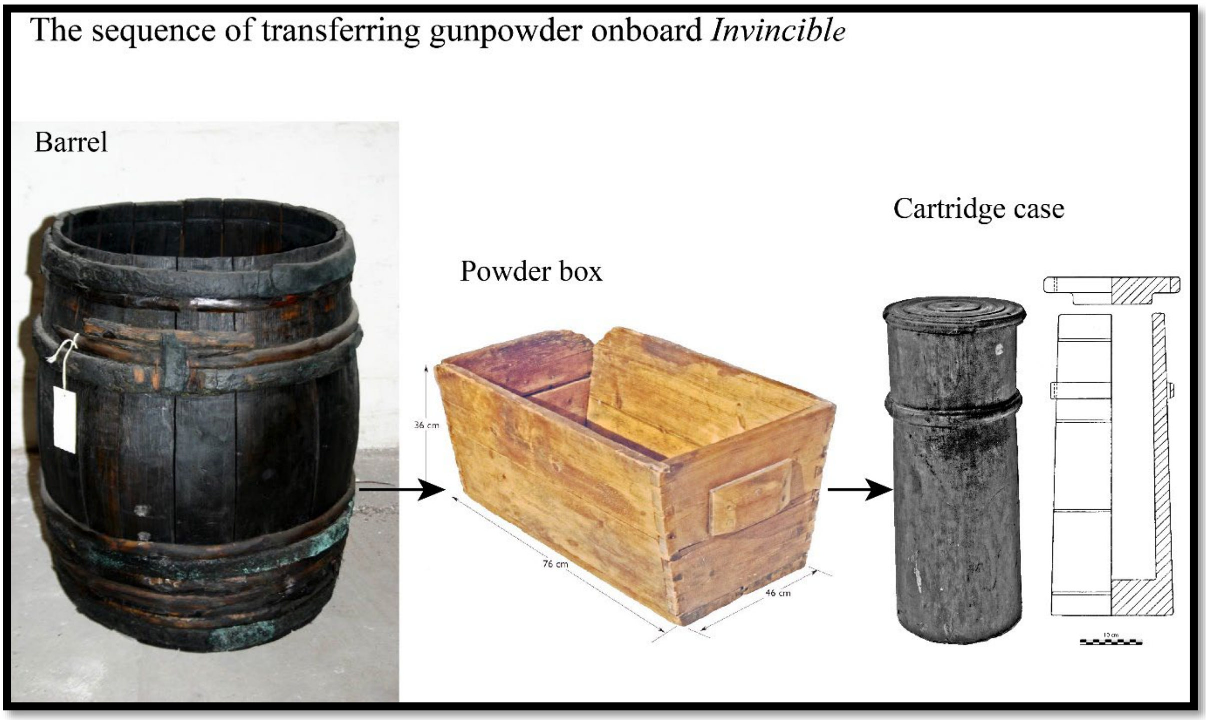

Figure 7.49: Transfer of powder from barrel to cartridge case. The archaeological evidence from the filling room and magazine has identified a very well organised and systematic procedure for the transfer of powder and making of powder charges for the guns, the significance of which will be discussed in chapter nine (Images courtesy of J. Bingeman).

7.4.3 *Wadding and Junk*

Supply

The importance of wadding is often overlooked, possibly because its ephemeral nature leads to poor preservation in the archaeological record, with the exception from within the barrels of recovered guns. These rather mundane objects were, however, essential in the loading and successful firing of the guns and hundreds of them had to be ready and available for use in action. A note dated April 1779 under the junk inventory in an ordnance and store list for ships of each rate, stated one third to be in wads and two thirds in junk (TNA ADM 160/150). A 74-gun warship would carry up to seven ton of junk for foreign service (TNA ADM160/150). When the ready-made wads were running low, a task of the crew was to pick the yarns from the junk to make more wads.

Organisation

As with the shot, a certain amount of wads would have been placed close to each gun station for immediate use. Archaeological evidence from the *Invincible,* however, shows that there was also a specific store for ready-to-use wads along with the junk, located in a section of the forward hold immediately below the gunner's store on the orlop.

The evidence from *Invincible* shows that there were three sizes of wadding to match the calibre of the guns on board, demonstrated by their string bags containing a wooden tally stick with the calibre of the gun (Figures 7.32,33 and 7.50). The exception being the 9-pounder, which was significantly smaller. It is highly likely that a bag of wads could be picked up and taken to a particular gun station when needed.

Figure 7.50: 24-pounder gunwad with tally stick nearby. The wadding is resting on top of the junk (Photo by Author).

This store of wadding is immediately below the gunner's store on the orlop. The internal plan of the orlop and hold of the *Valliant* shows a hatch on the starboard side of the gunner's store (Figure 7.51). This hatch enables access to the forepeak and other forward parts of the hold. It is possible that *Invincible* had a hatch here to, but this remains an assumption as this section of the deck in the gunner's store does not survive. However, a hatch grating was found displaced between the forward most surviving section of the orlop and the hold (Figure 7.52), an example of this can be found in a similar location on the forward orlop of HMS *Victory*. The hatch gratings allow light to be directed to areas of the ship below and they are easily removable to enable access. If the *Invincible's* grating was close to its original position, then this would have given the Master Gunner of *Invincible* good access to this awkward dead space, allowing the stowage of bulk items that would only be needed when stocks had run low. This is further evidence of all the space on board being utilised. Although the wadding in this area is surplus, if it is required quickly, for example, if there was a sustained period of fighting, then it has already been organised into bags of certain sizes and is ready to be taken to individual gun stations.

Figure 7.51: Orlop plan of the *Valiant* (based on the lines of *Invincible*) showing a hatch in the gunner's storeroom leading down to the forepeak (Image J8138 © the NMM, Greenwich, London).

Figure 7.52: Hatching grating found displaced immediately below the floor of the gunner's store on the orlop (Photograph by Michael Pitts).

The current excavation revealed that the wadding was piled on top of, and surrounded by, a nest of junk. The junk was laid in relatively short lengths that started at the very front of the forepeak covering a group of eight spare gun carriage axles, which were stacked between two breast hooks (Figure 7.53).

Figure 7.53: Spare gun carriage axles with junk lying on top (Photo by author).

This end of the junk was free with no other material on top of it. From there the junk cascaded down into the space where all the wadding was piled and stopped at a bulkhead, which separated this area from the filling room (Figure 7.54). By having one end of the junk free, lengths of junk could be pulled out when needed.

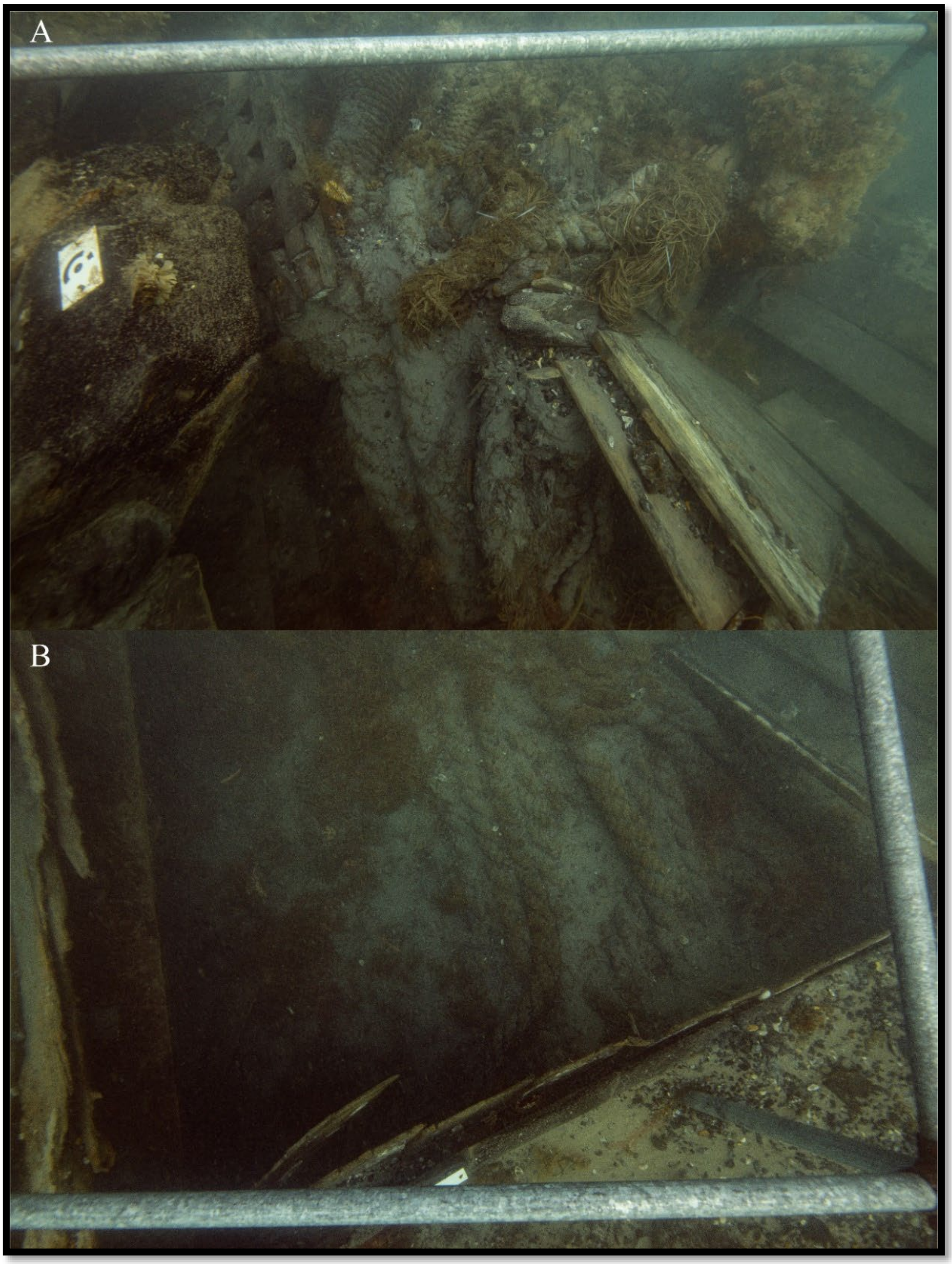

Figure 7.54: Photo A shows the junk cascading down from the forepeak into the space next to the lightroom. Photo B shows the other end of the junk butting up against the bulkhead forward of the filling room (Photos by Michael Pitts).

The bulkhead was constructed with planks of oak with thinner softwood (pine) planks fastened on top with iron nails. Plaster was found between the two layers of planking (Figure 7.55). Both layers of planking were butted edge-to-edge as opposed to the inverted overlapping planking found on the sides of the orlop.

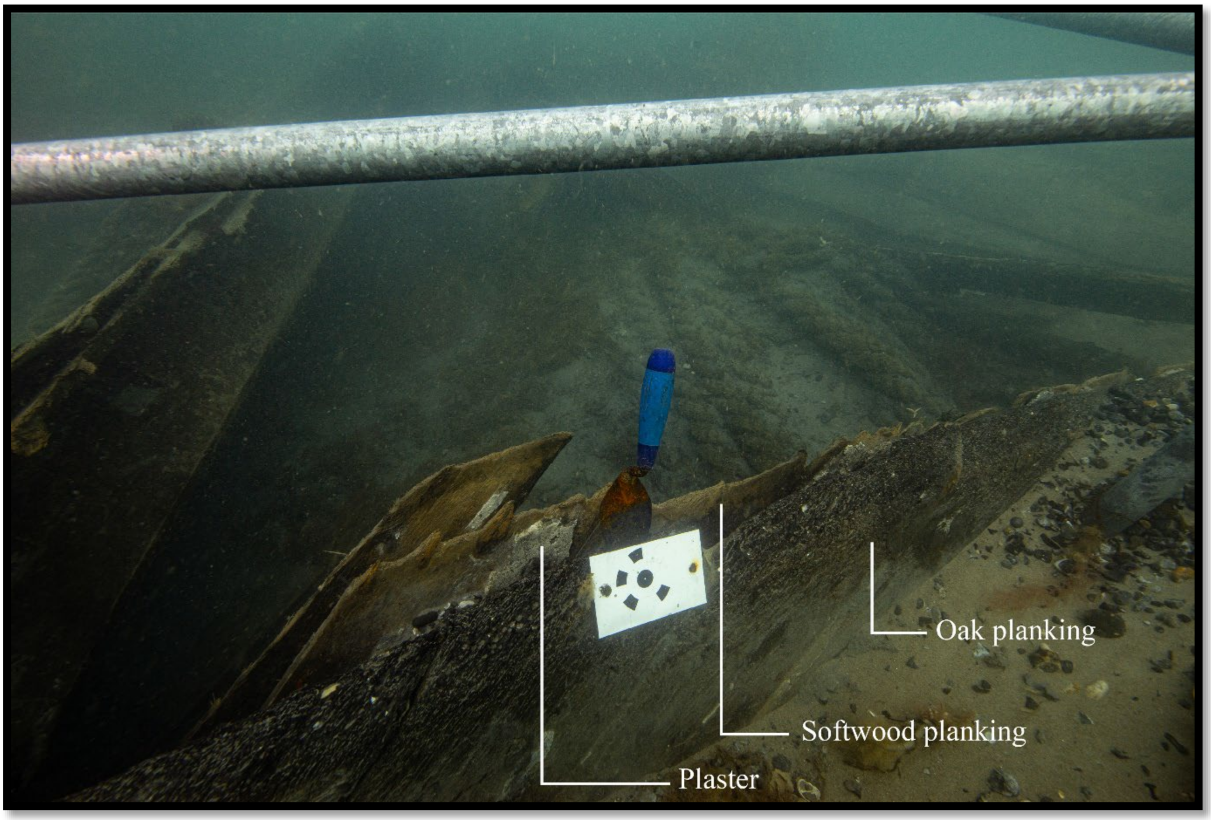

Figure 7.55: Photo showing the construction of the bulkhead separating the junk room from the filling room. It consists of a layer of soft wood nailed to thicker planking of oak with plaster in-between the layers (Photo by Michael Pitts).

It would have been important to access the junk before the ready-to-use wadding ran out, as this was not a situation the gun crews would want to be in. As such, it would have been necessary to produce more wadding regularly. The evidence from *Invincible* also confirms that a proportion of the junk was ready-made wadding and that this was occurring prior to 1779.

7.4.4 *Spare gun equipment*

Supply

The supply of the gun equipment found on the site has been discussed in section 7.3 above.

Organisation
The archaeological evidence has identified that the organisation of spare gun equipment was spread quite deliberately between the forward areas of the orlop and hold. Of course, it could be considered that the ship settled on the portside and this resulted in objects moving and accumulating on that side of the ship. Also, wooden objects would have been displaced or floated to different locations during the wrecking process. However, the neat stacking of coins and axles, for example, and location of wads and junk deep in the hull demonstrates that objects were found in either the exact place where they were stowed before the ship wrecked or in close proximity. It is possible to see a logical and deliberate method to the storage of much of this equipment.

Within the remains of the gunner's store on the orlop the equipment found was spare rammer and sponge heads, single and double blocks, tampion reels, hand crow leavers/hand spikes and staves/shafts for rammer heads (Figure 7.29). It is this type of equipment that was regularly used and most likely to wear out or break and therefore need to be replaced. It was also fairly lightweight and easy to store. It makes absolute sense to store this on the orlop where it was easily accessible at all times.

The heavier and bulkier objects like the spare carriage axles were possibly less likely to wear out so frequently and were therefore kept in the hold, as they would not have been needed so readily. Weight would be another reason, in that heavier objects are better stowed lower down in the ship, to maintain stability. All eight of the spare carriage axles were found together and stowed between two breast hooks. The breast hooks provide a large surface area and were therefore ideal for stacking the spare axles. To ensure the axles remained secure and undamaged during transiting the junk was placed around them. As mentioned in section 7.4.3 this area could be accessed from a hatchway in the floor of the gunner's store above and was therefore still reasonably accessible when required.

The location of spare coins and trucks seemingly neatly stowed in the port corner of the lightroom was quite unexpected and suggests their placement was deliberate rather than accidental (Figures 7.20 and 7.56). The discovery of a further 10 coins found immediately below the floor of the lightroom sandwiched between two lower breast hooks suggested even more were stored in the lightroom and that they had fallen down when the floor broke up. The main purpose of the lightroom was to provide a safe place for a guarded light to illuminate the filling room and magazine. Storing equipment here would create unnecessary hazards in a dangerous part of the ship. It is possible that the stowage of these pieces of equipment was temporary and that the crew were in the act of stowing them with the wadding in the space between the inside of the hull and the side of the lightroom. That would have required there being a side entrance in the lightroom to enable access to that part of the hold, which is possible as there was a section of panelling missing when excavated during the 2017-2018 excavations. If the stowage of gun equipment here was not temporary then this is another example of the crew utilising every bit of spare space to accommodate all of the ship's equipment and the crew's provisions for a long and arduous campaign in a remote and hostile part of the world.

Figure 7.56: Spare axles stowed between two beast hooks in the forepeak and coins neatly stacked in the corner of the lightroom (Photogrammetry survey, model and photographs by author).

7.5 Key points

The archaeology combined with the historical record presented in this chapter have identified several key developments and improvements that were made in the management, organisation and operation of the guns during the mid to late 18th century. These will be summarised below and expanded on in chapter nine.

1. Regarding the guns equipment there are two significant developments since the period of the *Hazardous* and that was with the design of the carriage and the method of firing the guns. The changes with the carriage led to a lighter weight but durable version that could be repaired more easily and kept in service for longer and the introduction of the gunlock ultimately led to more efficient firing and rapid rate of fire.
2. The archaeological evidence from *Invincible* has identified minor changes in design of key pieces of loading equipment.
3. The archaeological evidence has provided the most substantial evidence for the fittings and, specifically, the number of fittings necessary for securing the guns to the inside of the hull.
4. The types of shot have been reduced to three: round, double headed hammered and grape shot, with redundancy in the form of bars of iron and case shot. This would have made supply and storage of shot on board simpler.
5. The *Invincible* alongside contemporary plans has identified a main storage of shot in lockers fore and aft of the main mast and well, and that the majority of round shot was stored there with the smallest calibre at the top. The lack of double headed shot suggests it was stored in a separate compartment of the locker above the round shot. The discovery of significant amounts of the grapeshot at the location of the gunner's store demonstrates this less robust shot was stored away from the heavier types.
6. The *Invincible* has provided clear evidence of improvements in the storage and the safety of handling powder through the internal structures of the magazine and filling room and the accessories used for the transferring of powder from barrel to cartridge case.
7. The *Invincible* has shown a clear layout and organisation on the ship for gunnery equipment that utilises different areas, including what could be generally be perceived as dead space.
8. The inscribing and labelling of gunnery equipment shows there were improvements in production and manufacturing and that this was a product of standardisation. This also helps to organise and maintain the equipment on board and ensure the right equipment goes to the correct guns.
9. The greater organisation and maintenance of the gunnery system shows a high level of discipline and professionalism.

Chapter 8 HMS *Colossus* (1787-1798) and HMS *St George* (1785-1811)

8.1 Introduction to results for *Colossus* and *St George*

The results discussed in this section come predominantly from the authors' analysis of gunnery material that was recovered from the wreck of the *St George* during rescue excavations in the 1980s. The material was located at the Strandingsmusem St George at Thormindes, Denmark. The curators of the museum kindly permitted access to all artefacts on display in the *St George* exhibit and in the reserve collection in the museum stores. With the case of the wreck site itself the author has no personal experience from diving it, the understanding of the site and context of the finds relies entirely on two publications in English and the interpretations within the museum exhibit. Neither publication is a full report on the excavation, but they do include some useful interpretation of the remains and reasonably detailed sketches and measured plans showing the condition and extent of the wreck and distribution of key artefacts over several years. As a result, the precise location of the finds under investigation are not always known and, consequently, the understanding of the relationship between the object and its context is sometimes limited. This may change in the future after the more comprehensive write-up of the excavation. Until then, however, evidence from other sites of the period, including substantial evidence from the *Colossus,* as well as historical and iconographic records, have been incorporated in an attempt to contextualise artefacts recovered from the *St George*.

This chapter, therefore, combines predominantly the artefactual evidence from the wreck of the *St George* alongside the structural evidence from the wreck of the *Colossus*. The combination will enhance the knowledge and understanding of the developments in the Royal Navy gunnery during the Revolutionary and Napoleonic periods and identify developments since the mid-eighteenth century and the time of the *Invincible*.

The following sections 8.2 - 8.3 will introduce the sites of the *St George* and *Colossus* and explain which parts of the ships relate to the gunnery system. Sections 8.4 – 8.5 will then discuss the evidence found on the sites for operating the guns and for the supply, organisation, maintenance and operation of the gunnery system. Finally, section 8.6 will summarise the key points.

8.2 AN INTRODUCTION TO THE INVESTIGATIONS OF HMS ST GEORGE

In 1980 the site dramatically uncovered revealing that the wreck was lying upright, four metres proud of the seabed, and intact from the bow to the stern from the level of the main gundeck (Teisen 1998, p. 263, Jepsen 2019, p. 207). A sketch of the site by the lead diver, Gurt Normann Andersen, showed that much of the deck planking was still surviving. Where there were gaps in the planking, the deck beams supporting the planking could be seen traversing the entire breadth of the deck, demonstrating the integrity of the remaining hull structure (Figure 8.1). The main gundeck was home to twenty-eight 32-pounder Blomefield pattern guns, four of which were found in a group roughly amidships, others lay on the seabed along the port side and many, along with guns from the other decks, were salvaged during several salvage operations between the sinking and 1941 (Teisen 1998, p. 262, Jepsen 2019, pp. 201–203).

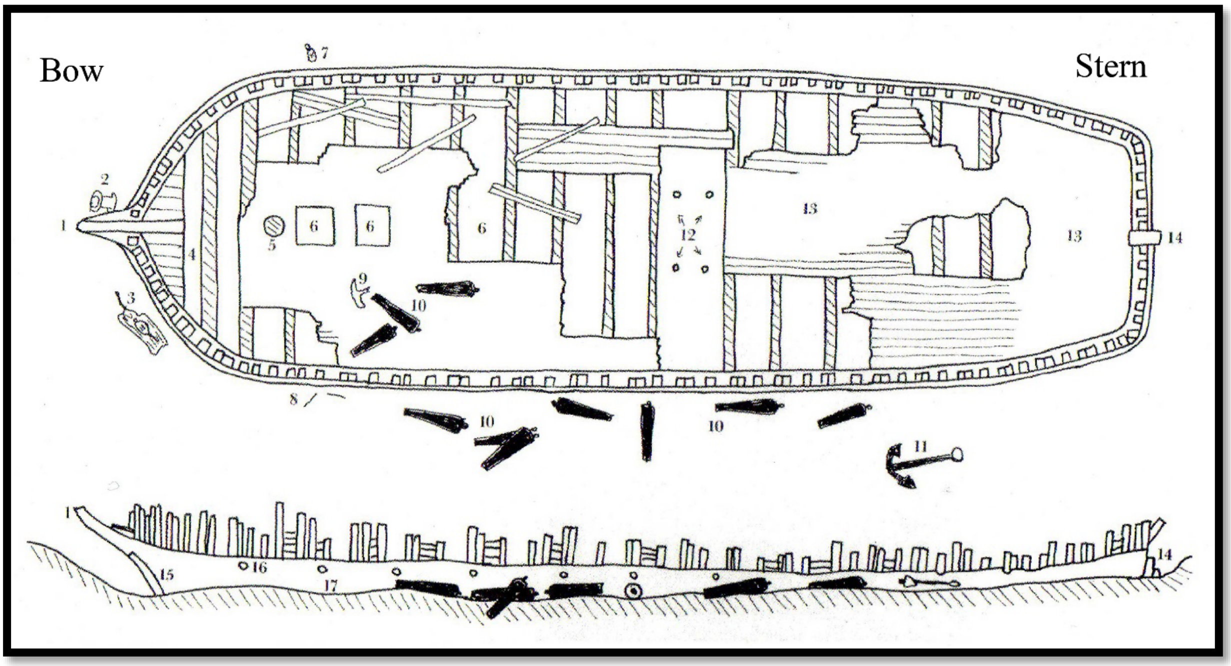

Figure 8.1:Sketch plan of the site in 1980 by lead diver Gert Normann Andersen (Image copied from P. Jepsen Publication (Jepsen 2019, p. 206)).

Another, more accurate, measured plan was made in 1982. This shows the survival of several hatchways along the centre line of the deck, leading down to the orlop, but winter storms in 1981 had caused the loss of much of the aft deck planking. Where the deck was missing at the forward end of the gundeck, divers were able to access the orlop (Figure 8.2). They confirmed the location of the gunner’s store on the starboard side. The room had the remains of two lattice doors in place, behind which were a variety of spare gun equipment and also kegs of lead shot and gun flints (Teisen 1998, p. 264, Jepsen 2019, p. 209).

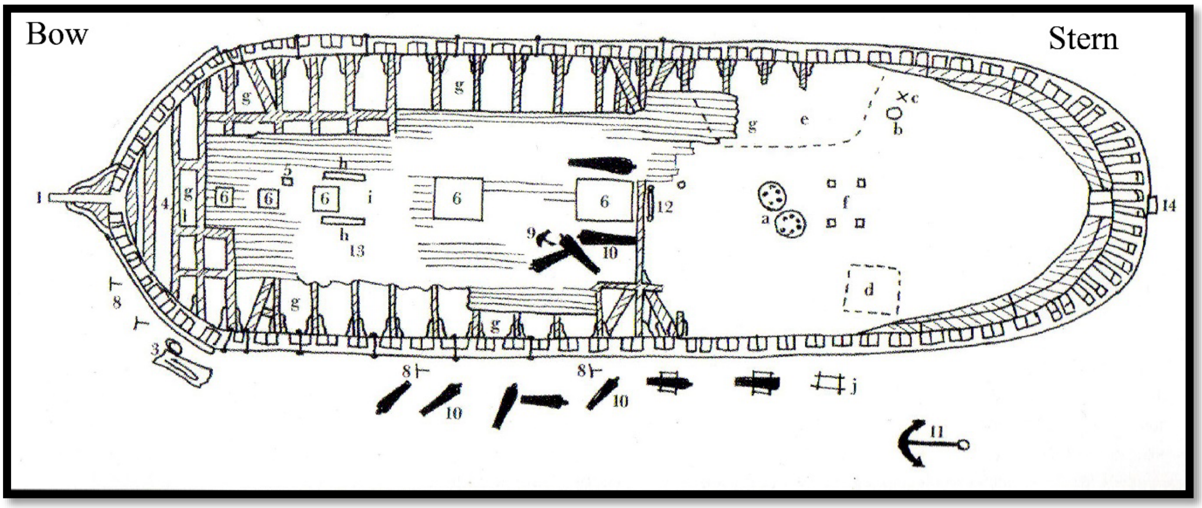

Figure 8.2: A measured plan from 1982 by lead diver Gert Norman Andersen. (Image copied from P. Jepsen Publication (Jepsen 2019, p. 206)).

In 1984-85, the site archaeologist Michael Teisen produced another measured plan of the site showing the loss of the aft end of the gundeck, including the deck beams (Figure 8.3). The loss of this structure and further excavation revealed other stores and cabin structures, but this area of the ship and the finds recovered from it are beyond the scope of this work. While the wreck remained exposed, it continued to deteriorate at a rapid rate and by 1986 the forward end of the gundeck was also washed away causing the loss of artefacts from the orlop. This led to the forward end of the orlop being the focus of the 1986 excavations and resulted in the recovery of much of the gunnery equipment under investigation in the sections below. As well as hundreds of small finds, seven guns were recovered: two long guns with carriages and five carronades, a third carriage was recovered but without it’s gun (Jepsen 2019, p. 214).

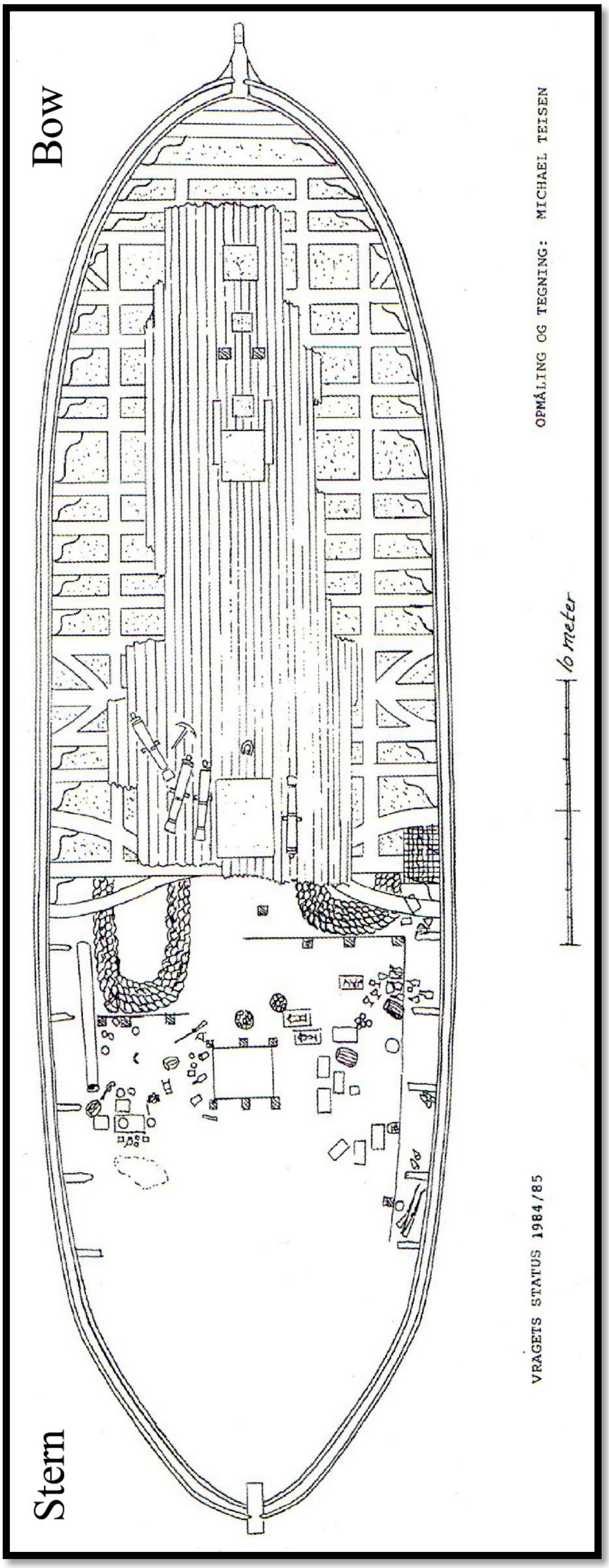

Figure 8.3: A measured plan of the site from 1984-85 by lead archaeologist Michael Teisen of the National Museum of Denmark. (Image copied from P. Jepsen Publication (Jepsen 2019, p. 208).

8.3 Introduction to the investigations of HMS Colossus

Since 2002 a large section of the port side has been recorded by Kevin Camidge's CISMAS team. Their investigations have shown that the port side survives from roughly in-line with the main mast to the stern and from parts of the quarter deck down to the deck level of the orlop. A total of 21 gunports survive, seven from each gundeck (Camidge 2017, p. 18). Like the *St George,* the *Colossus* had a main gundeck armament of 32-pounder Blomefield pattern guns and the structures and fittings around these guns were similar if not identical to that on the *St George*. Fortunately, Kevin Camidge and the CISMAS team have recorded the exposed structures in great detail, including the excavation and recording of one of the main gunport areas (Figure 8.18 in section 8.1.4). It is the structural information from that recording that is the focus of the evidence from *Colossus* and which will be described and discussed in section 8.4.5.

8.4 Evidence for working the guns from the St George.

The evidence for working the guns on board the *St George* comes entirely from recovered gunnery equipment. The equipment came from two main locations, the main gundeck and from storerooms located on the orlop. There were exceptions, such as the guns and carriages that were recovered from outside the wreck and which originated from the upper gundecks.

8.4.1 *Mounting and supporting the guns*

This section will first analyse carriages, gun furniture and equipment from the wreck of the *St George,* followed by an analysis of structural details relating to the operation and housing of the guns on the gundecks from the wreck of the *Colossus.*

Gun carriages from the *St George*

The rescue excavations of the *St George* have provided three of the most complete examples of a bracket and transom carriage recovered from a Royal Navy shipwreck. They exhibit several new details that have either not survived or were simply not present on previous examples. The carriages not only identify how the guns were mounted but their fittings show how they were secured, manoeuvred, and even kept functioning if the carriage was damaged, as well as components to prevent a malfunction. These features will be analysed in detail, as they will identify the improvements made to this type of carriage since the period of the *Invincible* and the *Royal George.*

The preservation of the left side of carriage **7546-12** was particularly good; it was even possible to see that it was painted red. The iron fittings were also in an incredible condition, as if they had never been underwater (Figure 8.4). As with the case of the *Royal George* carriage, the cheeks are constructed from two pieces of timber fastened together by five iron fixings driven down from the top, with the lower half lightened by the ubiquitous arch cut out of the bottom edge (Figures 8.4-5). The heads of the three aft bolts are flat and counter sunk into the forward end of the first, third and fourth steps (Figure 8.5 and 8.7). From the bolt that passes down from the first step it is possible to see that the bottom ends of the bolts protrude and are secured by a washer and forelock (Figure 8.6). The latter two iron components could be removed to knock out the bolts to replace damaged parts of the carriage.

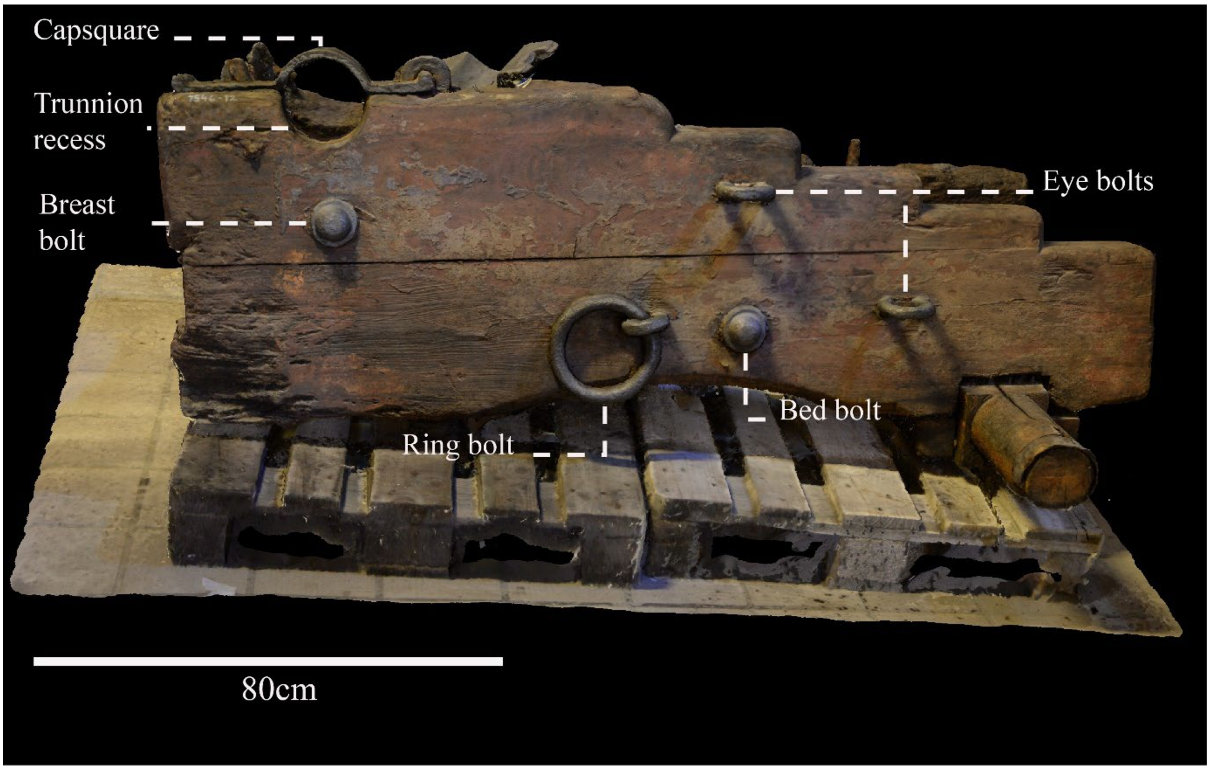

Figure 8.4: Photogrammetry model of carriage **7546-12** showing the left side (Model produced by author).

Returning to the front end of the cheek one can see the design of the capsquare has changed little from the time of the 17th century. The capsquare hinges on an eye bolt, which since the development of the transom and axle carriage extends down through the cheek, protrudes from the bottom and is fitted with a washer and forelock (Figures 8.4-5). The top end of the front capsquare bolt is slotted to allow a locking pin to secure the capsquare when placed over the trunnion of the gun (Figures 8.4-5). The bolt also passes down through the cheek and front axle. The trunnion recesses on these later carriages are significantly shallower than those of the truck and bed carriages and, as a result, the trunnions rest higher above the cheek resulting in the capsquares being more pronounced (Figure 8.4).

Figure 8.5: Photogrammetry model of carriage **7546-12**, showing the counter sunk iron fixings along the top of the cheeks (Model produced by author).

Directly below the trunnion recess is one end of the breast bolt. The preservation of the iron was so good that it was clear to see that the end was clenched over a rove (rivetted over a circular washer), the bolt passed through the cheek and transom timber and emerged on the outside of the opposite cheek (Figures 8.4). The next iron fitting is a ring bolt located centrally at the bottom side of the cheek. It consists of an iron ring inside an eye bolt, the end of the bolt is roved over a square washer counter suck into the inside of the cheek (Figures 8.4 and 8.6-7). This functioned to pass the breeching rope through. Immediately aft of the ring bolt is the bed bolt which, like the breast bolt, passes through to the other cheek and is clenched and roved at either end (Figures 8.4 and 8.6). Above the bed bolt is an eye bolt with another located aft and below the second step (Figures 8.4 and 8.6). Their function were for attaching the gun tackle; the upper eye bolt was used when housing the gun when not in use. The upper position did not interfere with a second 'preventer breeching'(Moody 1952, p.

306), which was presumably attached during rough conditions as was apparent from the *Stirling Castle's* recovered gun and carriage. Both eye bolts are clenched and roved over a square washer counter sunk into the inside of the cheek (Figure 8.7). There are two additional eye bolts, one fastened centrally to the rear face of the rear axle and another fastened centrally to the front face of the transom, but the front eye has been corroded away (Figure 8.5). The latter was for towing the carriage along the decks, most commonly performed when the carriages were delivered to the ship (Moody 1952, p. 306). The rear eye bolt was for attaching the train tackle, which was used to hold the gun inboard while it was loaded (Moody 1952, p. 306). All the edges of the cheeks are chamfered to an angle of 45º, which was a feature of carriages from 1791 onwards (Caruana 1997, p. 379) (Figures 8.4-5 and 8.7).

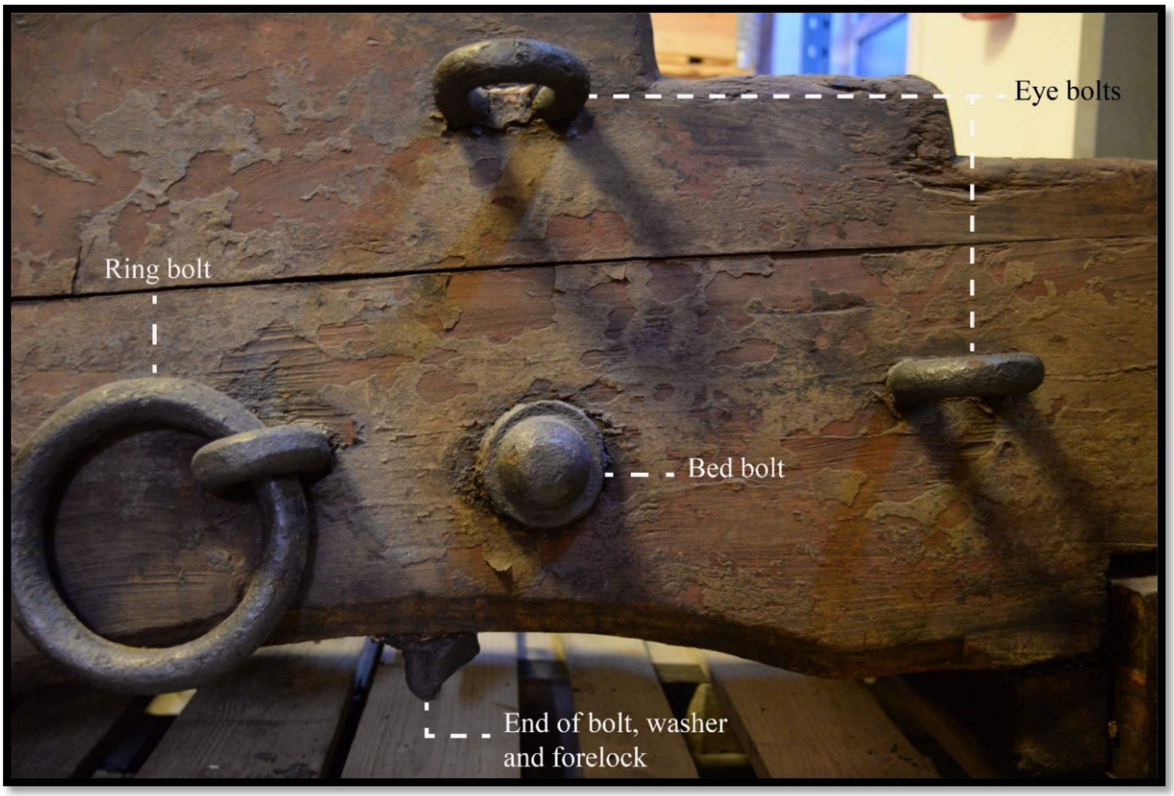

Figure 8.6: Photo showing lower end of bolt, washer and forelock (Photo by author).

The very fine finishing of the carriage is not merely for aesthetics but serves a genuine purpose. The chamfering around the edges would greatly reduce the splitting of the timber if struck by heavy objects or pieces of equipment; sharp edges will split or splinter. Sharp edges would also cause chafing to tackles and breeching, which could potentially lead to malfunction. The ends of bolts are either counter sunk into the timber or riveted. This ensures there are no sharp edges which could also chafe into tackles and breechings. These small details all combine to aid the maintenance and ensure the reliability of the gun when in operation.

Figure 8.7: View of the inside of cheek showing counter sunk roved over bolts and square washers (photo by author).

There are additional iron fastenings that are visible on carriage **6952-1**. There is an iron bracket re-enforcing each end of the front axle (Figure 8.8). One end of the bracket fits on to the bottom end of the rear capsquare bolt, the other end attached to the bottom of the axle. This bracket was also present on the carriage from the *Royal George*. On the underside of the corners of the rear axle there are 20mm thick metal plates (Figure 8.9). This was likely to add strength at the rear where there was the force of the weight of the breech of the gun. Caruana suggests this is why the ends of the hand crow leavers were shod with an iron shoe for protection (Caruana 1997, p. 396).

Figure 8.8: Photo showing concreted iron bracket bracing front axle with the bottom of the cheek (Photo by author).

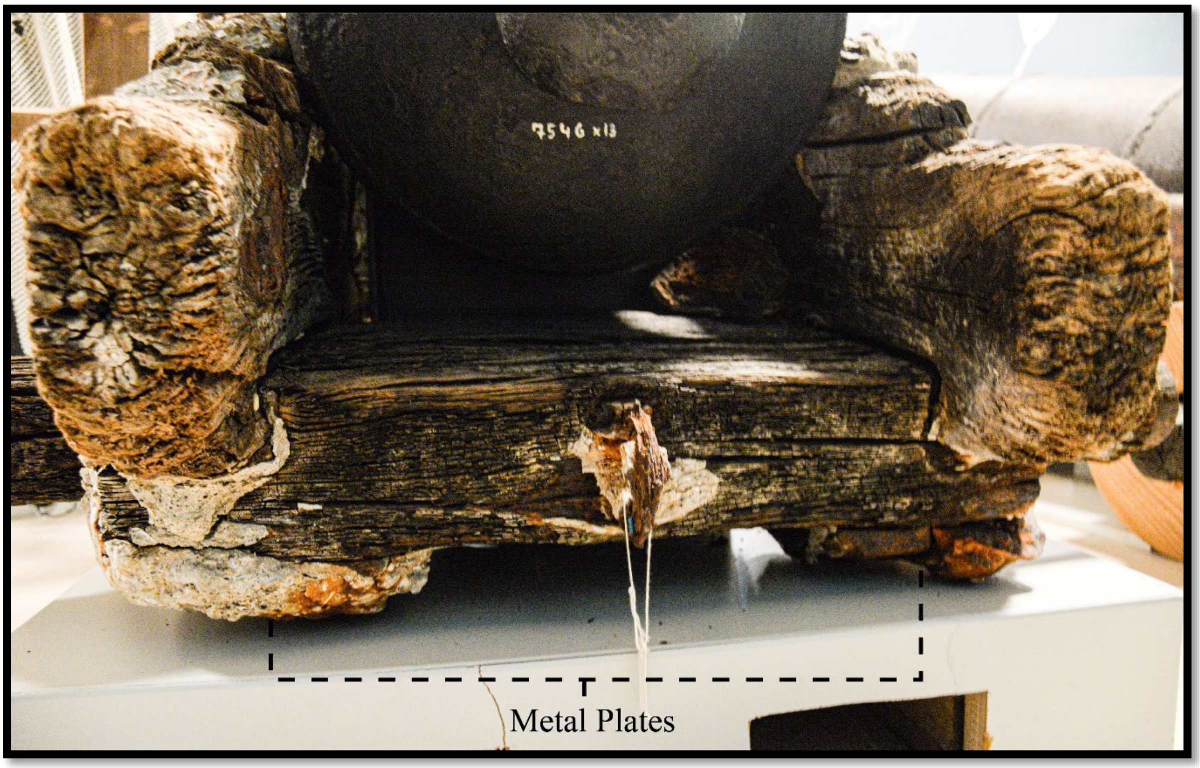

Figure 8.9: Photo showing location of metal plates on the underside corners of the rear axle (Photo by author).

From 1795, two additions were made to the ship's carriage: pieces of timber fitted to the front face of the cheeks and the side of the cheeks above the front trucks and axle. The former were known as breast pieces and the latter as preventer cleats (Figure 8.10) (Caruana 1997, p. 379). The breast piece was to ensure the carriage was kept at a fixed distance from the side of the hull and the preventer cleats were to keep the breeching and gun tackle from fouling the front trucks when the gun recoiled. Carriage **7546-583** has the well-preserved remains of one of the preventer cleats on the top right cheek (Figure 8.11). It is a wedged shaped piece of timber that is fastened on to the side of the cheek by several iron fastenings. It extends from just below the level of the top of the cheek down to the level of the top of the truck. Although this is the only one fixed to the carriage, all the carriages have fixing holes and markings in the shape of these cleats left on the surface of the cheeks. There are no breast pieces present but there are visible fixing holes and concretion staining on the front faces of the cheeks of all the carriages suggesting that they did have them (Figure 8.11).

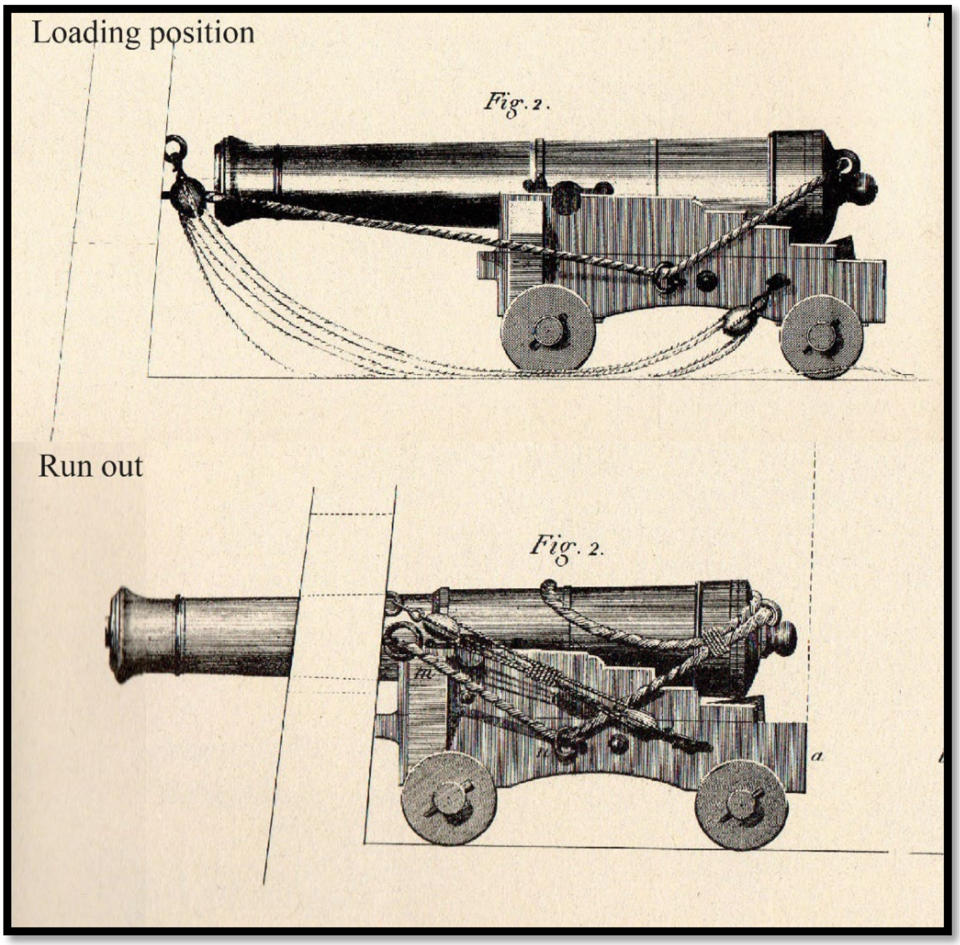

Figure 8.10: Illustrations taken from lieutenant Colonel William Congreve's 1811 Treatise on the mounting of Naval Ordnance. The illustrations show the standard sea carriage with the preventer cleats(on the sides) and breast piece (on the front) (Congreve 1811) .

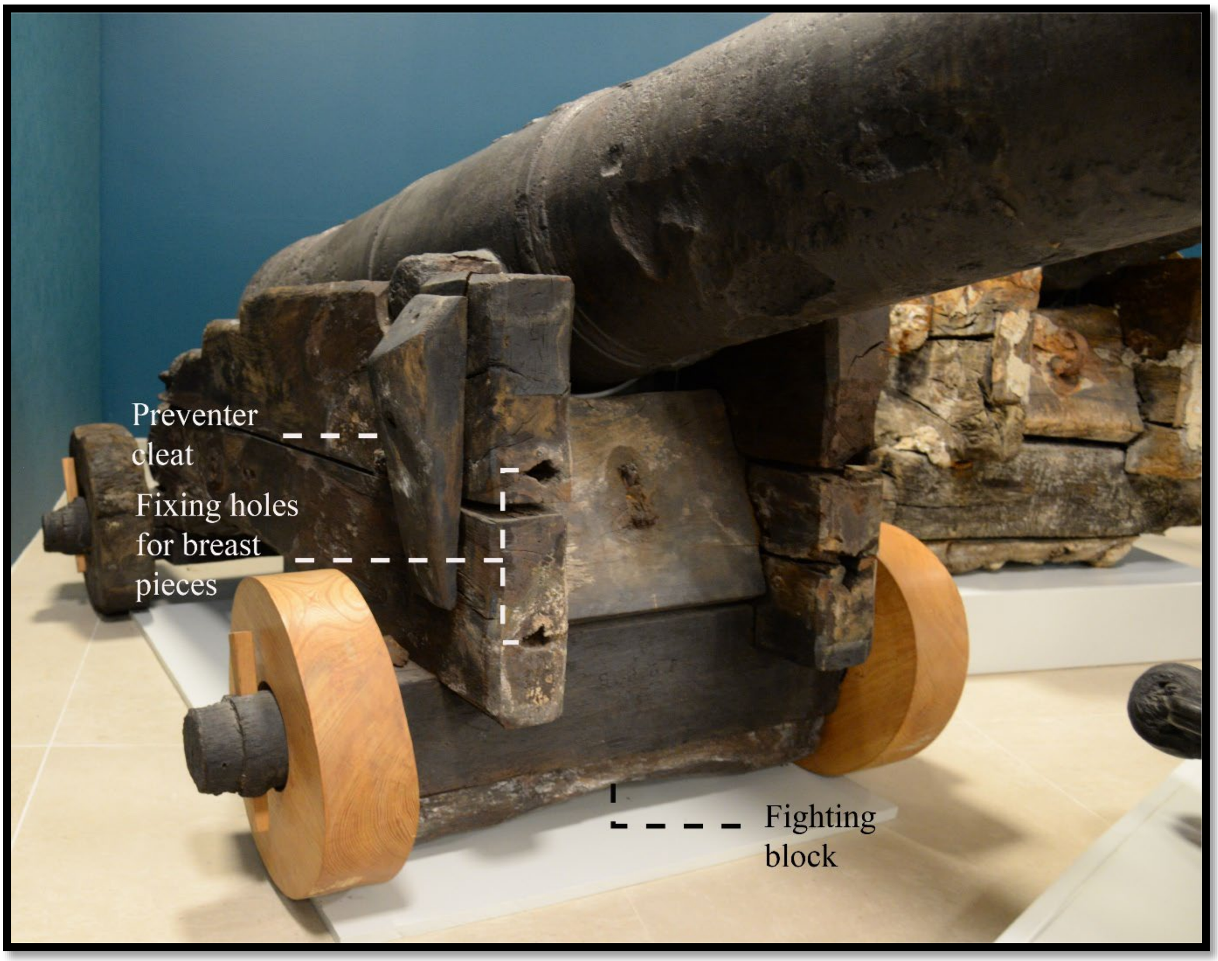

Figure 8.11: Photo showing preventer cleat on the side of carriage **7546-583** and possible fixing holes and outline of horns on the front of the cheeks (Photo by author).

There is one other addition present on carriages **6952-1** and **7546-583** and that is a plank of wood fastened to the underside of the front axles. The plank almost completely fills the space between the bottom of the axle and the deck (Figures 8.11-12). This piece of timber was known as a ‘fighting block’ and it functioned to stop the carriage turning over should the truck(s) break (Moody 1952, p. 308). This meant the gun could continue to be operated during an action.

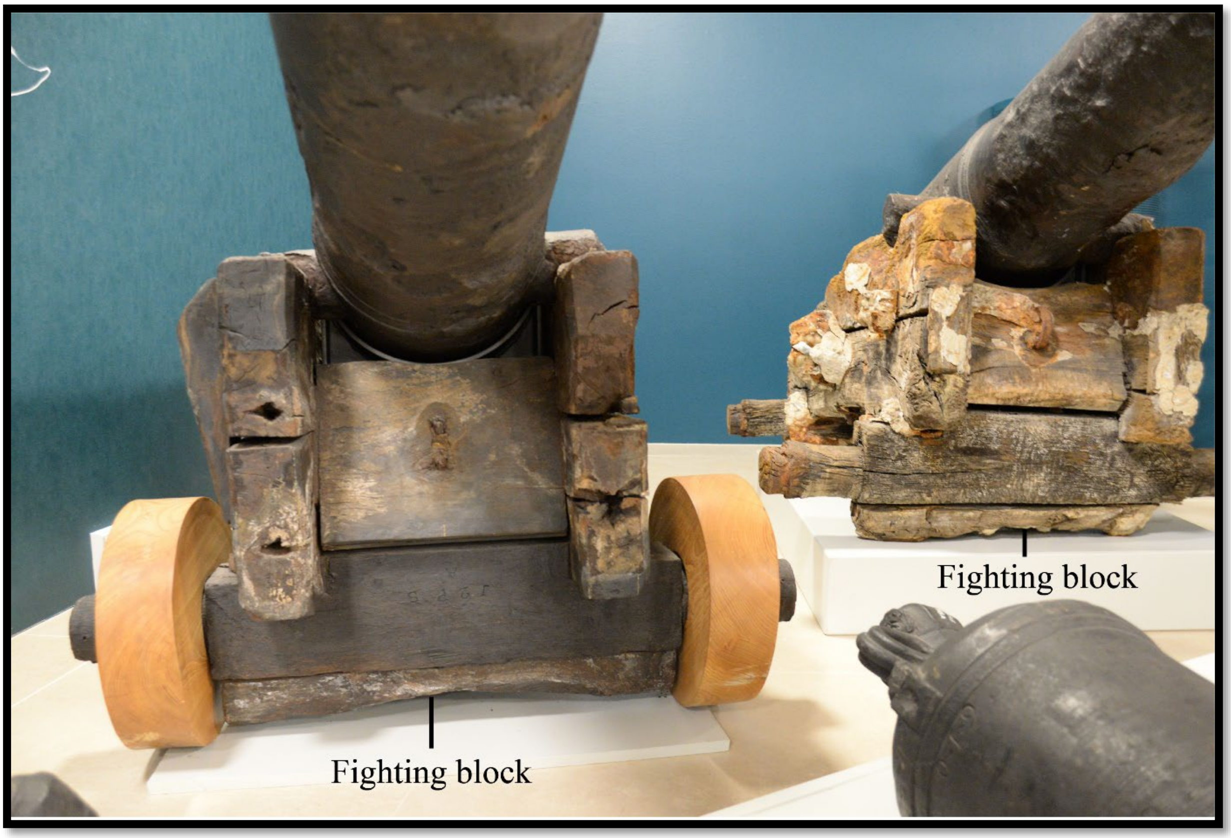

Figure 8.12: Photo showing the fighting block attached to the underside of the front axles of carriages **6952-1** and **7546-583** (Photo by author).

In addition to the three carriages a single piece of a carriage cheek was recovered. It is the top piece of a cheek, which includes the trunnion recess and capsquare fixing holes (Figure 8.13). It has been dressed along the top with chamfered edges; the bottom face is a clean cut with undressed edges to sit on top of the lower section of the cheek. There are the remains of iron nails and small pieces of corroded iron within the main capsquare bolts, suggesting this was attached to the rest of the cheek, rather than a spare piece. The inventories of gunner's stores do not list spare carriage cheeks (TNA WO55/1745 and TNA WO55/1749), which would suggest cheeks parts would have to be made-up on board by the carpenter from spare timber. From the evidence of complete transom carriages, each cheek is made of two halves. This piece, consisting of only the top piece above the trunnion recess was, therefore, likely to be a repair.

Figure 8.13:Photos showing the top piece of a carriage cheek, probably made as a repair (Photo by author).

Coins for coining guns

In section 7.3.1 of chapter 7 it was established from the analysis of inventories of gunner's stores that each gun along with its carriage was issued with one coin and one stool bed. The *Invincible* has shown this coin was a simple wedge shape with the calibre of the gun carved onto the rear face, which rested on the stool bed, which was also marked with the calibre of the gun. From *c.*1747, we see from the inventories the additional introduction of another type of coin referred to specifically as a coin for coining guns. The wedges found on *Invincible* with the staggered fixing holes and cut-out corner, described in section 7.3.1, have been interpreted in this thesis as a potential contender for this type of coin but it is far from certain as one will see.

According to the key of the proportions of stores, for all rates of ships, from *c.* 1779 up to the Napoleonic wars, ships of 100 to 80 guns were issued with two of these types of coins to every gun on the lower and middle gundecks. Following this, all guns on the lower and middle decks would have been issued with one stool bed and coin, plus two coins for coining guns, three coins in total. For the latter type there was also one spare to every seven coins (TNA ADM160/150). The fact that there were spares suggests that the primary coins were kept near the guns. The *St George* had 28 guns on the lower gundeck and 30 guns on the middle gundeck, resulting in 116 coins for coining guns assigned, with 16 spares.

Four almost identical examples to those found on *Invincible* were recovered from the *St George* (Figure 8.14). They are likely to be spares as they were found in the gunner's store. They have several features that stand out, including a square cut-out section, the alignment and distance between the fixing holes, and the angle of the incline, all of which suggest they had a specific function. Logic would suggest the purpose of the cut-out section was to either ensure it did not interfere with part of the carriage, gun, or equipment, or two fit alongside a specific part of the carriage. The bolt holes suggest the coins were fastened to either the carriage, the deck or with another coin. Generally, coins for elevating the guns were moveable pieces of equipment to make quick adjustment to the gun's elevation, so any fixing would have to be quick release to restore the gun to a normal firing position or to change the elevation of the gun. With the exception of the capsquares and linchpins, to secure the trucks on the axles, the fixings on the *St George's* carriages are not quick release and they do not line up with holes on the coins. There are no fixing holes either on any part of the carriages that line up with the holes on the coins. For these reasons it is doubtful that this type of coin was fixed to the carriage.

Figure 8.14: Four possible coins for coining guns (Photo by author).

Fixing these coins to the deck would also create an issue of release and it is therefore equally unlikely that they were fixed to the deck. The fixed alignment of the bolt holes suggests the coins were used in tandem and fastened to one another.

With both the *Invincible* and the *St George* these coins have been found as spares in or around the location of the gunner's stores. As no examples have been found associated with a gun carriage, and the fact there is no iconographic evidence illustrating these coins in context, it is a challenge to understand how they were used and positioned in relation to the gun and carriage. Adrian Caruana has provided a confident explanation for these types of coins, stating:

''*Every British warship carried spare carriages, separated into their component parts, so that damaged carriages could be repaired. A thoughtful Board of Ordnance provided jackscrews and ''coins for coining guns'' to jack up a carriage or raise a gun clear of its carriage while such repairs were carried out…''* (Caruana 1997, p. 362).

This would appear to be a plausible explanation, however, the 1779 key to the proportion of stores specifically states that they were for the lower and middle deck guns, yet carriages on the upper decks would still require potential repair if damaged. Furthermore, the high quantity of these coins does not make sense for use for repair as you are unlikely to need to repair so many carriages at the same time. Another issue is that there are no references to jackscrews in the inventories. There are, however, such things as hand screws, but a 98-gun ship was only issued with two, so if these were used together this would negate the need for so many coins. Unfortunately, Caruana does not provide a reference to corroborate his explanation and the above analysis severely casts doubt upon it.

Michael Duffy, in his paper on gunnery at Trafalgar, may inadvertently have provided a possible use for these coins in action. He describes how the starboard guns of the middle and lower decks of *Victory* were depressed when aiming at the French ship *Redoutable*. Depressing a gun is the reverse of elevating, so the breech end is raised to lower the muzzle. As well as depressing the guns they were triple shotted to reduce their velocity. The reason for this was the location of another British ship *Temeraire* on the other side of the *Redoutable,* the *Victory's* Officers did not want their shot to travel through the *Redoutable* and into the *Temeraire* (Duffy 2005, p. 153). Angling the guns down to aim at the waterline would also smash holes below the waterline and potentially sink a ship or, at the very least, take crew away from the action to work the pumps. The coins for coining guns could have potentially been used to give added assistance with raising the breech end of the gun to point the muzzle of the gun down. While the middle and lower deck guns are potentially aiming low the upper deck gun would continue to aim at the upper parts of the opposing ship and therefore the upper gundeck guns would not need the extra coins.

The gun can only be elevated or depressed to a certain degree before the muzzle comes into contact with the port sills. There was a solution to this problem described by Major General Howard Douglas in his '*Treatise on Naval Gunnery'.* Douglas states if the required depression is greater than the port will accept then inclined planes should be placed under the rear trucks and for elevation under the fore trucks. This allows an increase in the angles of depression or elevation of two or three degrees (Douglas 1982, p. 390). The coins from the *St George* and the *Invincible* are wedged shaped, so they have an incline, and placing them under the trucks would raise the carriage. The staggered holes could have assisted in fastening the coins to the trucks, so they did not separate when the gun recoiled. It is difficult, however, to understand the purpose of the staggered bolt holes and cut out corner for this use.

8.4.2 *New feature of securing the guns present on the guns.*

Two cast iron long guns and five carronades were recovered from the site, but only the long guns will be included in this section. They are of the Bloomfield pattern, which was first in service from 1787. One of the most noticeable features of this pattern, and relevant to this section, is the breeching loop cast at the top of the button. (Figure 8.15) This simple adaption allowed the breeching rope for the gun to be threaded through and held by the loop at the cascabel without the need to splice the breeching rope around the button to hold it in place. This saves time preparing and securing the gun but it also made operating the gun safer as splices had the potential to slip and jump off the button or even break; the breeching loop took this danger away.

Figure 8.15: Photo showing breeching loop above the button of the 12-pounder Blomefield pattern gun (Photo by author).

8.4.3 *Dressing the gun*

Lead Aprons

All the guns including the carronades were issued with aprons. They had evolved since the period of the *Invincible* to accommodate the cannon lock, which was attached beside the vent hole at the breech end of the gun. The aprons have therefore been designed with an upstanding moulded hump to the right side of the apron, which would sit over the cannon lock, with the other half flat to cover the vent hole. The aprons were embossed with the intended gun calibres as well as two broad arrows in the left corners. The examples studied from the *St George* were for guns of 32 to 18-pounder calibres (Figures 8.16). Similar examples have been found on the wreck of HMS *Pomone*, including ones embossed with carronades 42P, 32P, 24P, 18P and 12P, which shows the apron could fit all sizes of carronade ranging from 42-12 pounders (Bingeman 2010, p. 127, Bingeman et al 2021, p. 26).

Figure 8.16: Photo showing a lead apron appropriate for 32-18-pounder guns (Photo by author).

Tampions
There appears to be very little change in the form of the tampion and the inventories still show that there were several spares for each gun (TNA ADM160/150). One tampion was extracted from the muzzle of 12-pounder gun **7546-13***,* it was drilled through the centre and had a cord attached which dangled a gun wad. A wax sealant was also found around the edges of the tampion. The purpose of the wad was to soak up moisture in the barrel and the wax sealant assured the barrel stayed dry. The excavation of the barrel revealed that the wax, along with a tight fit, kept the barrel dry for the 173 years it was underwater, the round shot, wads and even the cartridge were in a near perfect condition (see Figure 8.23 in section 8.4.6).

8.4.4 *Manoeuvring the guns*

Hand crow leavers
According to the proportions of ordnance stores for each rate of ship dated from 1790, but which extends to the period of the Napoleonic wars, a 98-gun ship would have been issued with 147 hand crow leavers, including 87 six feet long and 60 five feet long. Those of six feet long were issued to the 32 and 18-pounder guns and those of five foot were issued to the 12-

pounder guns and, according to the 1790 proportion of stores, three hand crow leavers were shared between two guns (TNA ADM160/150). Several hand crow leavers were recovered in various states of completeness. Hand crow leaver **6000-4067** was a complete example and will be described in detail (Figure 8.17). It was 1825mm (5.99in) long and can therefore be categorised as one of the six feet long examples. At the head it is rectangular in section with the heel cut at 45 degrees. The inside face of the head is shod with an iron shoe and fastened by five iron nails. The length of the head is 605mm and the shaft is ovoid in section. The design, including the iron shoe, has not changed since the *London*. The thick iron plates under the corners of the rear axles of the *St George's* carriages show why it was necessary to shod the hand crow leavers with iron shoes as, without, the timber would have been easily chewed-up and its working life drastically shortened.

Figure 8.17: Hand crow leaver **6000-4067** shod with iron shoe (Author's photos).

8.4.5 *Structural evidence from the Colossus relating to securing, housing and training the guns*

In 2012 CISMAS excavated one of the seven surviving main gundeck gunports and surrounding structure. The structure survives in its entirety from the deck level of the main gundeck to the deck of the upper gundeck above, providing much of the evidence for securing, housing and even training the 32-pounder Blomefield pattern guns (Figure 8.18) (Camidge 2012). The gun and indeed all the other main gundeck guns were missing, having exited through the gunport during the wrecking process.

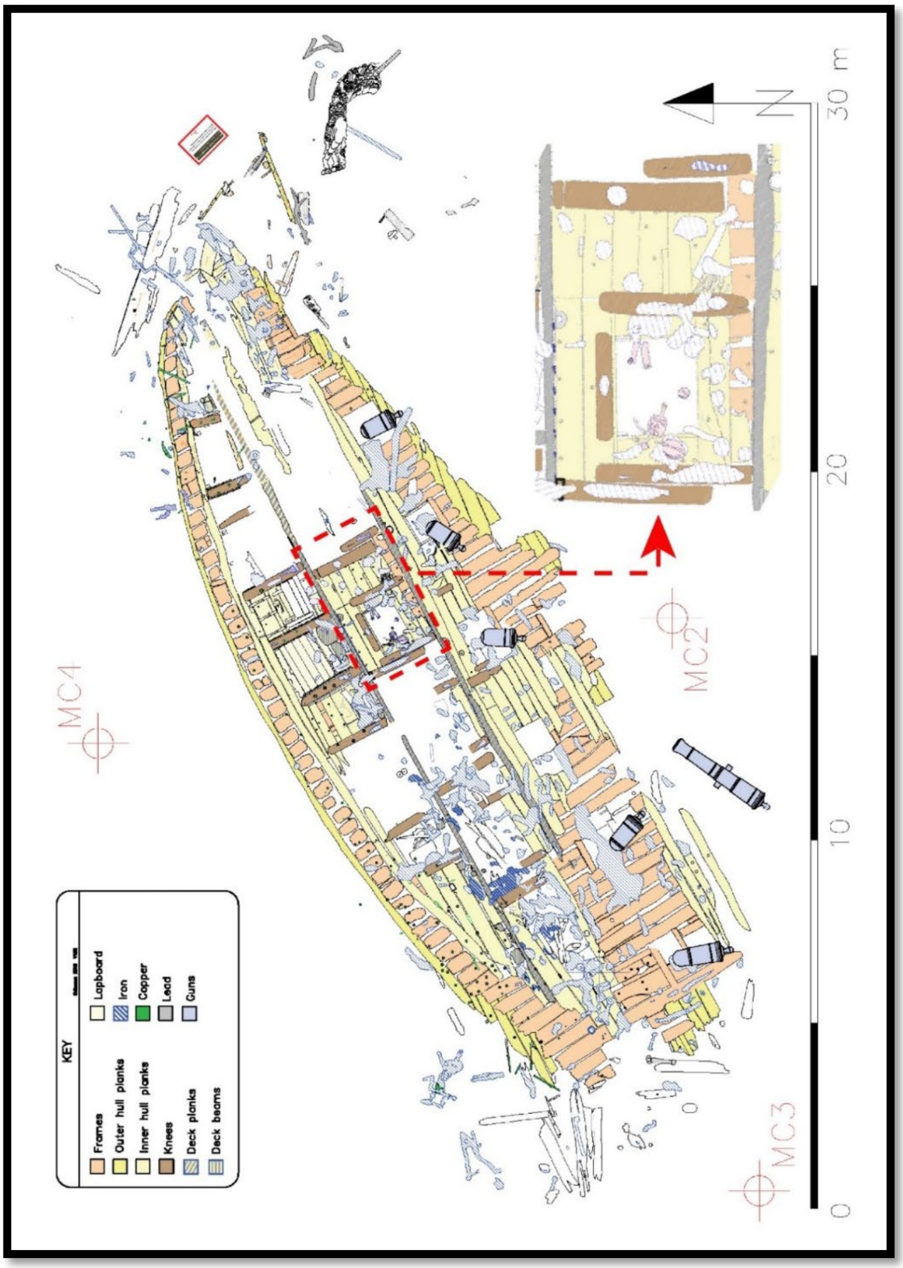

Figure 8.18: The site plan of *Colossus* showing an inset of the gunbay from the main gundeck that was excavated (Courtesy of K. Camidge and CISMAS).

The inside of the port is surrounded by several timbers and concreted iron fastenings, some with the purpose of re-enforcing the deck with the sides of the hull structure and others to accommodate the housing, securing and training the gun (Figures 8.18-20) (Camidge 2012, pp. 32–38). Beginning with re-enforcing timbers, on the aft side of the port are the remains of a wooden hanging knee and, on the forward side, a hanging knee and rising knee side by side (Figures 8.18-20). These knees are fastened to the inside of the hull by iron bolts, which can be seen from the areas of concretion on the inner faces (Figure 8.18). Between the knees and the sides of the port are concretions with ends of breeching rope attached and one double 10-inch block seemingly still connected by its concreted moused hook (Camidge 2012, p. 62) (Figures 8.19-20). These concretions are therefore also likely to be a combination of the remains of the eye and ring bolts for attaching the gun tackle and breeching rope. The location of the concretions are reasonably consistent with the concreted ring bolts found on the *Invincible's* aft most gun port which featured previously in section 7.3.2. Another double block was found inside the port. Both were marked with the markings RS and 10, the latter referring to the size of the block in inches (Camidge 2012, p. 40). These are typical 10 inch double blocks for use with the forward gun tackle. A single block was also recovered but the width of its sheave and sheave slot was too small to accommodate the rope found with the double blocks (Camidge 2012, p. 40). It is possible that this block was part of the tackle for raising the gunport lid.

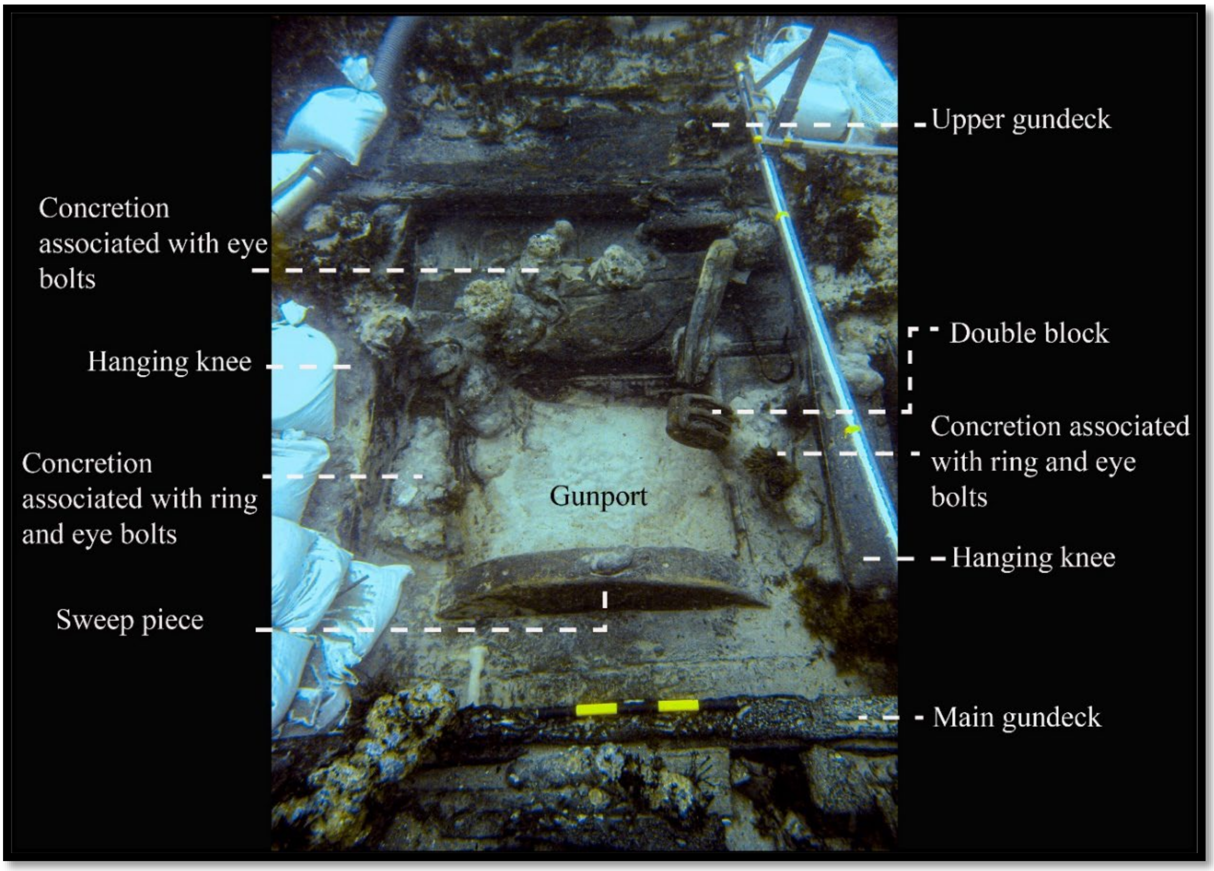

Figure 8.19: Photo showing the main gundeck gunport from the *Colossus* (Photo courtesy of K. Camidge).

There are two other concreted fixings on the inside of the hull above the gunport with abrasion on the timber immediately below (Figure 8.19-20). The concretions are the remains of eye bolts that were used to secure the muzzle lashings when the gun was run in and housed. Reconstructions of these fixings are present on board HMS *Victory* (Figure 8.21) and Congreve illustrates how the gun was housed and lashed in his treatise of 1811 (Figure 8.22). The abraded surface of the timber above the port on *Colossus,* along with the concreted eye bolts, is consistent with Congreve's illustration (Figures 8.20-22).

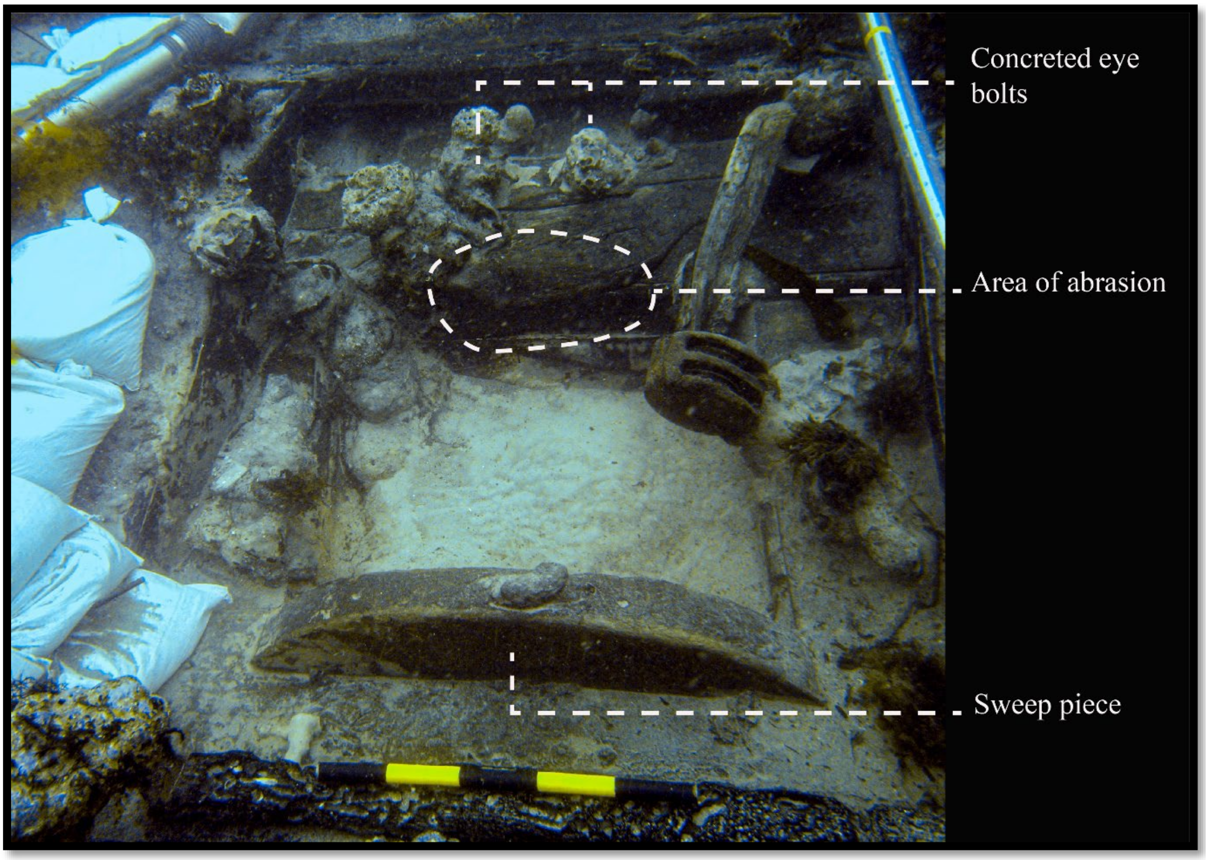

Figure 8.20: Photo showing features around the gunport, including wear marks and concreted fastenings above the port, sweep piece inboard of the port sill and iron fastening on the side of the port (Photo courtesy of K. Camidge).

Figure 8.21: Fixings around a gunport on board HMS *Victory* including two eye bolts above the port (Photo by author).

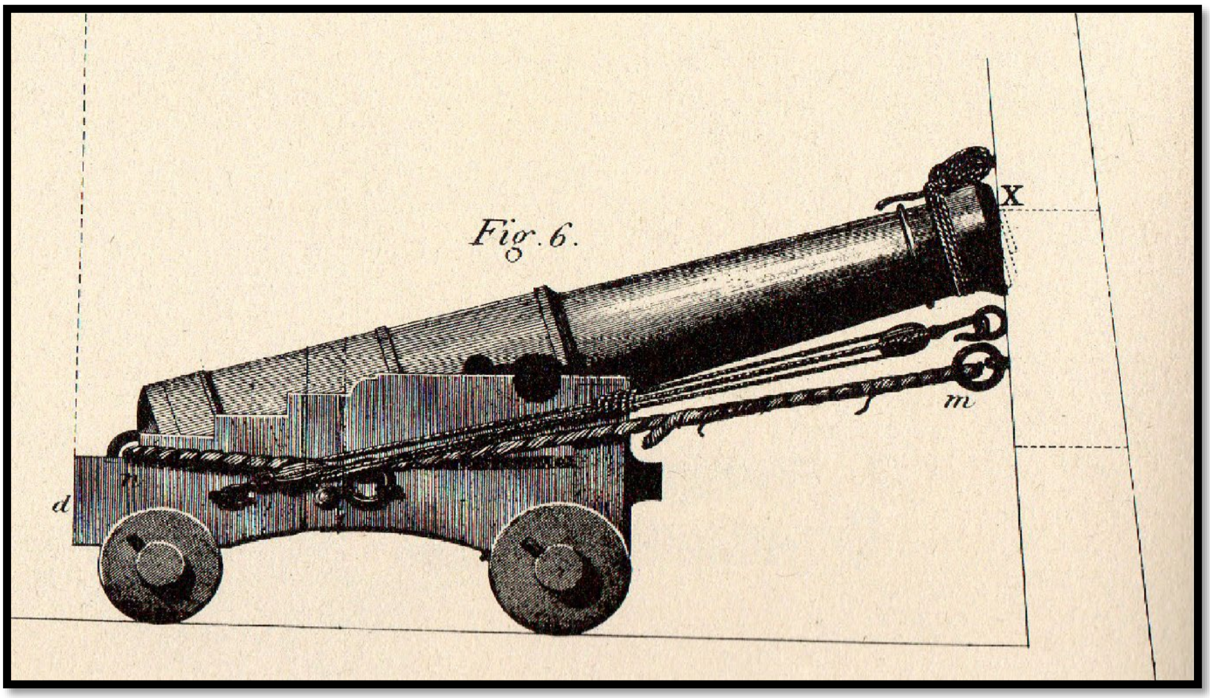

Figure 8.22: Illustration of the gun housed with the muzzle lashed against the top of the port (Congreve 1811).

Immediately below the port sill, fastened to the inside of the hull, is a timber that is slightly longer than the length of the width of the port and curved at either end (Figures 8.19-20). At the time of the excavation it was referred to as a 'stop beam' with a likely function to stop the carriage bumping up against the inside of the hull when pulled into the firing position (Camidge 2012, p. 38). This research has found two other possible explanations for this timber, the first is that it functioned to keep the front trucks of the carriage out of the waterways along the side of the deck (Moody 1952, p. 306). The decks were cambered to allow water to drain to the sides and out through lead pipes in the side of the hull, known as scuppers. When the gun was run-out the trucks could potentially restrict or deviate the flow of unwanted water. The second described a block of timber at the bottom of the port-sill, known as a sweep piece, which functioned to receive the chock (breast piece) of the carriage and to aid training (Smyth 2005, p. 669). With regard to the latter point, Camidge also suggested that the curvature of the timber would enable the gun to be trained forward or astern of the beam (Camidge 2012, p. 38). This theory also tallies with the experiments of the naval gunnery expert, Sir Charles Douglas, an experienced Captain who fought alongside Admirals Rodney and Hood at the Battle of Saintes on the 12th April 1782 (Wilson 2014, p. 331). Douglas modified the structures around the gunports to enable guns to be trained at different angles. This included adding ring bolts between gunports to allow the guns to be secured at an angle. This increased the gun's arc of fire and meant that a ship could attack more than one ship at a time: attack a ship moving away, or at distance, and even a single ship at different angles (Wilson 2014, p. 369). It is highly likely that the sweep piece coincided with this method of attack as it provided a solid structure for the carriage to be positioned against at an angle.

This timber and/or the breast piece attached to the front of the carriages would also stop the heavy impact on the trucks against the side hull when run out and was therefore also a method of preventing damage to the more vulnerable trucks. The sweep piece may have been introduced in tandem with the introduction of the new Blomefield pattern gun. The most visible difference between the Blomefield and the old Armstrong pattern was the addition of a breeching loop cast above the button of the gun (Figure 8.15). This allowed the breeching rope to run smoothly around the cascabel, which was especially useful when firing the gun at an angle. Prior to the Blomefield breeching loop the breeching was fixed around the button, which caused issues when the gun was fired at an angle as it created unequal pressures on either side of the gun (Lavery 2009, p. 82). *Colossus* was issued with Blomefield guns on the main gundeck and Armstrong guns on the upper decks. Looking at the *Colossus* site plan there are clearly no sweep pieces present below the lower sills of the upper deck ports (Figure 8.18). This could infer that the main gundeck guns would have been preferred for aiming at a target off centre.

8.4.6 *Loading the guns*

The contents of the barrel of the 12-pounder gun **7546-13** will demonstrate what that particular gun was loaded with and how the load was maintained in the barrel of the gun while it was not in use. Further evidence comes from spare and used loading equipment found in the gunner's store at the forward end of the starboard side (Teisen 1998, p. 266).

A loaded gun - The contents of the 12-pounder gun from the *St George*

The barrel of the 12-pounder gun **7546-13** was excavated and found to be loaded, as one has come to expect, but, perhaps less common, was the fact it was double shotted (Figure 8.23). The contents of the barrel were in an almost perfect state of preservation, due to it being protected from the ingress of seawater by the seal of the tampion at the muzzle end and the wooden plug at the touch hole. The seal between the tampion and the inside of the muzzle was maintained by a wax/tallow sealant and, along with the tight fit of the tampion, it kept the inside of the barrel dry. The shape of the tampion is the same as those found on the *Invincible*, tapered, so to fit snuggly inside the muzzle (figure 8.23). At the centre of the inside face of the tampion was the head of a rusty nail, which was where the first wad was attached by a cord. A second wad was attached to the first by another, thicker cord. The purpose of these wads was to soak up any moisture in the barrel. It is not uncommon to see one wad attached to the tampion as seen from the contents of a barrel of 32-pounder carronade from HMS *Pomone*, wrecked also in 1811 (Bingeman 2010, p. 115, Bingeman et al 2021, p. 24), but to have two could be a first for the current archaeological record. Behind these wads came the charge, which included a wad, two pristine round shot, another wad and then the powder charge within a flannel powder bag (Figure 8.23).

Figure 8.23: Photo showing the contents of the barrel of the 12-pounder gun 7546-13. Note it was double shotted (Photo by author).

One can see how the wad between the powder charge and the shot has a slightly larger diameter than the shot, which would have succeeded in creating a seal to stop gases escaping around the shot when the charge would have been ignited (Figure 8.23). This would have been especially necessary when double shotting a gun. If using the same charge as one would for a single shot then the velocity of a double shot would have been reduced, which was the intention. Double shotting was for close range tactics to cause maximum damage. High velocity single shots at close range had the potential to pass cleanly through one side of the hull and out through the other. A double shot, on the other hand, would have less velocity but cause more damage by smashing and splintering the hull; large broken off splinters of timbers flying around the decks would cause more fatal injuries than a shot going clean through. Although the intention of double shotting was to reduce velocity, one would not want it to be further reduced by poor wadding, as this may cause the shot to have little impact.

The wads were all made of handpicked yarns and wrapped in the same style as found on the *Invincible* (Figure 8.24). Three of the wads were in near-perfect condition and show the intricate pattern of the final wrapping around the main body of the wad. Their condition helps demonstrate the importance of the final wrapping as it holds the wad tightly together. It would have taken considerable skill and care to produce wads of this quality and it is more likely that these were manufactured ashore rather than on board.

Figure 8.24: Photo of the first wad extracted from the barrel, note the intricate pattern of the wrapping (photo by author).

Rammers

According to the proportions of stores for a 98-gun ship from the Napoleonic period, each gun was still issued with a rope sponge and rammer and there were spare rammer heads of one to every two guns (TNA ADM160/150). Four rammer heads were studied from the collection. Two appeared to be unused spare heads as they had no fixing holes for the fastening of a timber stave or rope. (Figure 8.25) There were no signs of wear around the edges of the ramming face, although there were some signs of biological decay. Rammer **6000–AU** was inscribed on the upper face with the number 18, demonstrating that this rammer was for use with the 18-pounder guns. There was no visible number inscribed on rammer **6000-AT** but the diameter of 112mm (4.4inches) across the ramming face, identified that it was suitable for a 12-pounder gun.

Figure 8.25: Two unused spare rammer heads. On the left rammer **6000-AU** and on the right rammer **6000-AT** (Photo by author).

Rammers **6000-4011** and **7546-967** were of the timber staved type and had been clearly well used from the degree of wear around the edges of the ramming face (Figures 8.26-27). Rammer **6000-4001** has a max diameter of 110mm (4.3in), which makes it appropriate for a 12-pounder gun. There were no gun size markings on the top side or any other part of the head. The hole for the stave is tapered, wider at the top than the bottom. This allows the stave to be pushed tightly into the hold. For added security, a single iron nail was present in the recess below the shoulder of the rammer. The edge of the ramming face is rounded off fairly evenly all the way round. This not only shows it was well used but it was also a tight fit with the bore of the gun. Rammer **7546-967** has a maximum diameter of 100mm (3.9in), which makes it appropriate for a 9-pounder gun. This is odd as the smallest great gun on board was a 12-pounder, which had a bore size of 117mm (4.62in). It is conceivable that the size discrepancy was the result of wear from regular use. There was no gun size marking on the top side or any other part of the rammer.

Figure 8.26: Rammer **6000-4011** (Photo by author).

Figure 8.27: Rammer **7546-927** (Photo by author).

Sponge heads

One possible sponge head for the great gun was studied from the collection. There were two other artefacts that appeared to be sponge heads, but they were too small to be for use for even the smallest of the long or carronade guns on board the *St George* and will therefore not be included in this analysis. Artefact **6000-AV** is slightly unusual compared to sponge heads found on the *Invincible*, *Hazardous* and the *London*. The length of the head is much shorter and it has a distinct neck with the remnants of a thin copper collar fastened by three copper nails. The function of the collar is probably to stop the thinner neck of the head from splitting (Figure 8.28).

Figure 8.28: Sponge head **6000-AV** (Photo by author).

A note dated the 18th July 1794 within the original 1779 proportions of stores for each rate of ship states that ships were to be issued with sponges of 1/3 old pattern, 1/3 Cook's and 1/3 fleecy hosiery (TNA ADM160/150). Cook's sponges were a new patent pattern invented by Mr Cook but there is neither a description for his patent or the fleecy hosiery type (Caruana 1997, p. 312). It is possible that this example from the *St George* represents one of these different patterns. Reconstructions found on board HMS *Victory* are similar in form with the distinct collar. With the *Victory's* sponges the sponge material slides onto the head like a sock (Figure 8.29).

Figure 8.29: Rope sponge on board HMS *Victory* showing similar collared style head to that found on the *St George* (Photo by author).

There are no other fastenings or holes made by fastenings on the body of the head, which suggests it was not covered by the sheepskin. If this is a sponge head, its size would suggest it was intended for use with the 12-pounder guns and the size of the through hole would suggest a solid stave instead of a rope sponge.

8.4.7 *Unloading the guns*

Ladles

A 98-gun ship would have been issued with four ladles to each calibre of gun for use on the gundecks, a further two to every 10 guns were issued as spares (TNA ADM160/150). Two ladles were recovered from the site, they are composite objects consisting of a wooden body, similar in design to a rammer head but with a copper scoop attached around the body of the head (Figures 8.30-31). Example **7546-284** was in a better state of preservation and will be described in detail. It is a ladle intended for a 32-pounder according to the marking on the upper face of the head. The head is pierced with the remains of a broken wooden stave. The hole is tapered, being smaller at the end of the scoop. The stave is secured in place by a single wooden peg that enters at the recess below the shoulder. The head is turned from a single piece of wood, with the rebate for a collar and the scoop 80mm wide, encircling the entire circumference of the head. The top end of the head has a narrower neck with the remnants of a copper collar fastened by three copper nails. The scoop only survives around the body but it is secured to the head by a copper collar and copper nails. The copper collar is more clearly shown by ladle **6000-3302** (Figures 8.30-31).

The design of the ladle has not really changed since the earliest examples found on the *Mary Rose*. They are essentially a rammer head with a copper scoop attached. The only difference between the ones from the *Mary Rose* and those found on the *Invincible* and *St George* is a stylistic one. The greatest change was in their function and this occurred quite early on at some point after the *Mary Rose*, when it was realised that the ladle was not necessary to load a powder charge contained within a cartridge. As soon as this was realised the number of ladles issued reduced and they were mainly used to get the load back out if there was a miss fire (Povey 1702, p. 30, Caruana 1997, p. 398). The ladle would be used to remove the shot and the powder charge and the worm, also known as the wad hook, was used to snag and retrieve the wads (Caruana 1997, p. 398).

Figure 8.30: Photo of ladle **7546-284** (Photo by author).

Figure 8.31: Photo of ladle **6000-3302** (Photo by author).

8.4.8 *Firing the guns*

Cannon locks

The primary method for firing the guns on board the *St George* was with the use of cannon locks. These were in widespread use in the Royal Navy during the last decade of the 18th century (Caruana 1997, p. 389) and by 1811 all the guns would have been issued with this firing mechanism. According to the proportions of stores they were made of brass, as they were referred to as brass cannon locks, and there were at least two patterns in use post-1793

(TNA ADM 160/150). There were also two sizes: those appropriate for guns of the 32 - 9-pounder calibres and those for 6 - 4-pounder calibres (Lavery 1987, p. 143, Caruana 1997, p. 389). The *St George* would have been issued with just the larger as the smallest guns on board were 12-pounders. The evidence for gun locks on the *St George* comes from recovered gun locks and lead aprons with the ubiquitous hump (Figures 8.16 and 8.32) to cover the upstanding gun lock screwed to the side of the raised touch hole of the Blomefield guns (Figure 8.33).

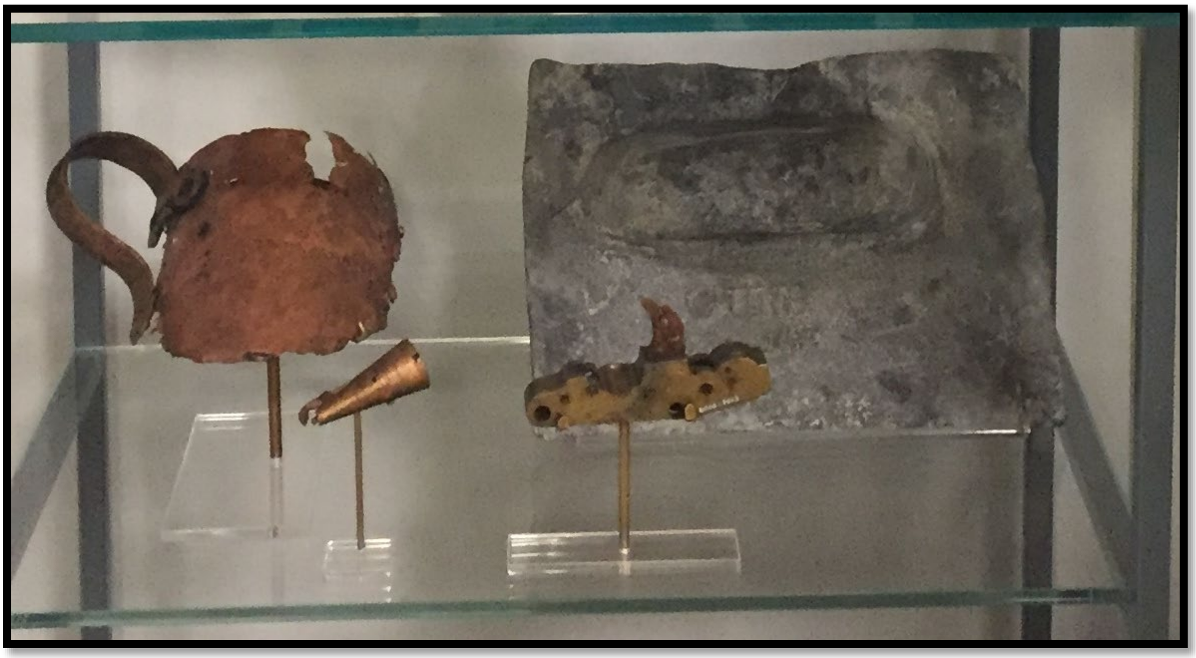

Figure 8.32: Photo showing an example of a cannon lock recovered from the *St George* and currently on display (photo by author).

The cannon locks recovered from the *St George* have a body made of brass with moving parts, such as the trigger, cocking handle and striking plate, made of iron. The archaeological evidence from the wreck of HMS *Pomone*, a 38-gun frigate, wrecked on the Needles, off the Isle of Wight also in 1811, identifies that there are two types of cannon lock in use at that time (Bingeman 2010, p. 128, Bingeman et al 2021, p. 25). One type is inscribed with the name of the manufacturer ‘W Dick’. Walter Dick was producing gun locks for the Navy by at least 1787 and in 1791, in partnership with John Knubley, produced a new pattern, which was submitted to Thomas Blomefield for approval. Neither Walter Dick or John Knubley were the main lock producers; that credit goes to Henry knock (Caruana 1997, p. 392). The second type found on HMS *Pomone* is identical to the ones found on HMS *St George*. The main difference would appear to be that it lacks the brass loop at the rear for guiding the lanyard to the trigger.

The locks were attached to the right side of the raised platform around the touch hole by two threaded bars that passed through the lock and out through the left side of the raised platform (Figure 8.33). The pan of the cannon lock would line up against a shallow channel to the right of the vent hole, which would be filled with priming powder and ignited by the spark of the flint hitting the striking plate.

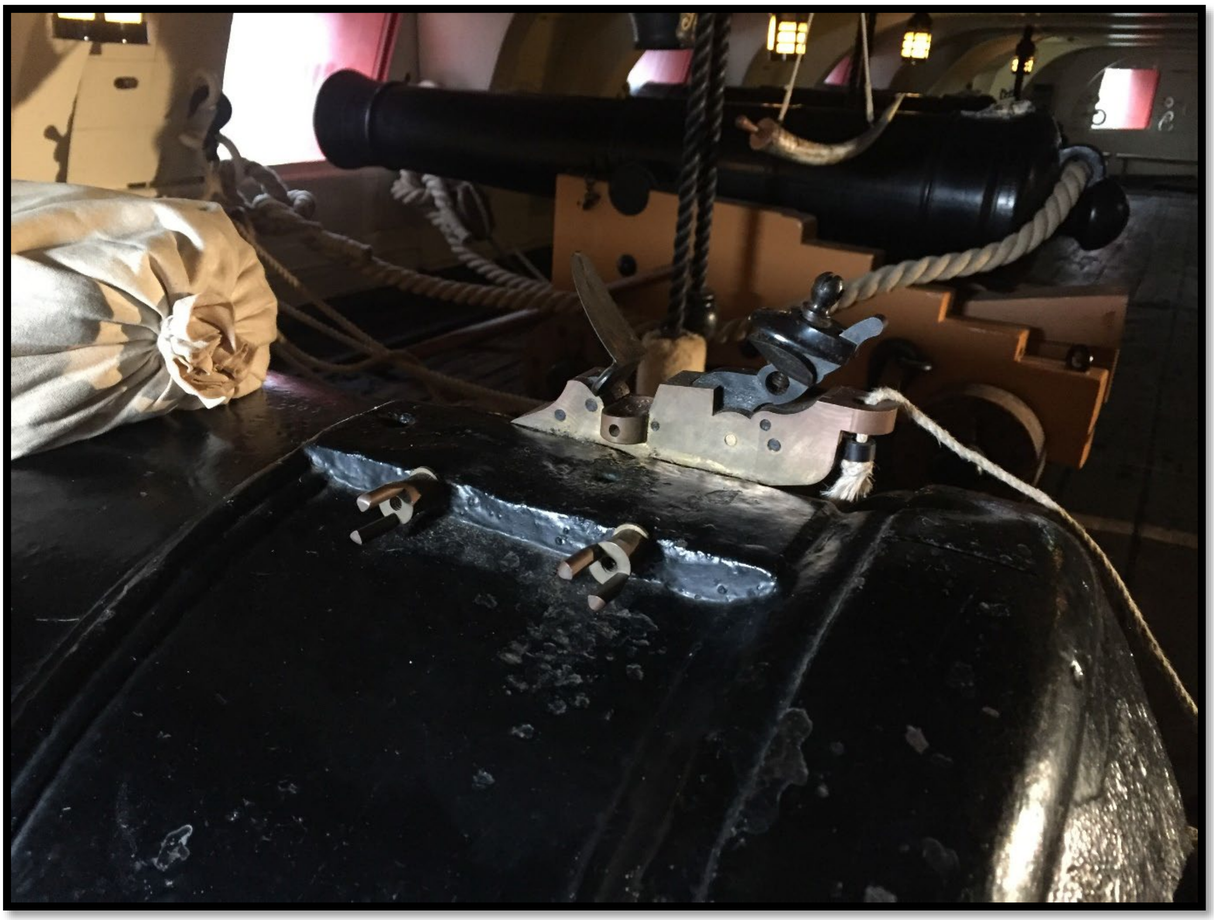

Figure 8.33: Photo showing a replica cannon lock secured beside the raised touch hole of a 32-pounder Blomefield pattern gun on board HMS *Victory* (Photo by author).

8.5 Evidence for supply and organisation of the gunnery system

Shot

The plans of the 98-gun Duke class second-rate ship of the line demonstrate that the main storage of shot was in shot lockers in the hold, and in front and behind the main mast (Jepsen 2019, p. 42). As the focus of the excavations was on the vulnerable and exposed gundeck and orlop, the shot lockers in the hold were not investigated. Instead the *St George* provides evidence for the storage of shot at the ready on the main gundeck. In previous chapters it has been established from both the archaeological and historical record that there were significant quantities and various types of shot kept on the gundeck for immediate use. There has, however, been no physical evidence of the actual holders containing the shot or evidence relating to their specific location on the decks and the iconographic evidence has also lacked detail. The level of preservation and intact nature of the gundeck, when first exposed, has led to some of this information surviving and being recorded for the first time.

Divers working on the *St George* observed round shot clustered around the hatchways along the centre line of the gundeck (Jepsen 2019, p. 207). Along with the observations of shot, two types of shot holders were recovered. The first type is constructed from a plank 233mm wide and 70mm deep with four surviving 160mm diameter circular recesses. The diameter of the recesses are appropriate for a 32-pounder round shot (Figure 8.34). The design of this type of holder is consistent with the 1780 order to cut holes around the hatchway coamings (Lavery 1987, p. 150). This type of holder has also been reconstructed and placed along the outside edges of the hatchway hatch coamings on board HMS *Victory*, with the exception of the side at the top of a stair case (Figure 8.35) (McGowan 1999, p. 211).

Figure 8.34: Photo of type of shot holder surrounding the hatch coaming along the centre line of the deck (Photo by author).

Figure 8.35: Photo showing the reconstructed shot holders along the edge of the main hatch on the main gundeck (Photo by author).

The second type of shot holder is much more of an intricate design consisting of multiple interlocking wooden parts (Figure 8.36). It forms a square of four rows and four columns consisting of 16 circular recesses to hold round shot. This is a mobile unit that could be moved to various locations in the general vicinity of the guns. To avoid interference with the working of the guns it was likely that this was located along the centre-line of the deck, probably in the spaces between the hatchways.

Figure 8.36: Mobile unit for holding shot (Photo by author).

As well as round shot, double headed hammered shot was found on the gundeck (Figure 8.37). The form is identical to the double headed hammered shot found on the wrecks of the *Stirling Castle* and the *Hazardous* in section 6.4.1 of chapter six. It is made of wrought iron bar hammered at each end to form the diameter of the bore of the gun. This confirms at least two types of shot for immediate use were stored on the gundecks.

Figure 8.37: Photo of hammered double headed shot **7208-3** (Photo by author).

Powder

The archaeological evidence from the *Invincible* in section 7.4.2 of chapter seven has demonstrated that on ships of 74 guns and above the main magazine was located in the forward part of the hold, aft of the forward mast. By 1716 it was realised that, on the large ships of the line, to maintain an efficient supply of powder to all areas of the gundecks there was the need for multiple powder rooms. The larger ships were therefore fitted with middle and aft powder rooms, albeit smaller than the one forward. After 1730 they were located in the hold or hanging between the orlop and hold along the centre line. The latter was known as a hanging magazine and the top of it was above the level of the deck of the orlop, which allowed the powder cartridges to be passed out (Lavery 1987, p. 145). The evidence of the after hanging magazine was observed in 1982 along the centre line of the orlop deck, between the mizzen and main mast, but other than its general location there appears to be no further information (Jepsen 2019, p. 206). The bulk of the hanging magazine would be in the hold, but this part of the wreck was not exposed and therefore not a priority for investigation.

Archaeological evidence from the wreck of the 74-gun HMS *Venerable*, lost in 1804, has demonstrated that the powder cartridges were still being transported from the magazines to the guns in lidded wooden cartridge cases, which were still referred to as cases of wood in the inventories (TNA WO55/1749). Their design had not changed since the 1650s as discussed in section 6.4.3of chapter six. The examples found on *Invincible* in section 7.4.2 from chapter seven demonstrated that the lid and case were kept together by a thin loop of cord. It has been suggested that the cord also acted as a carrying handle and, when slung, the lid was held secure (Martin 2017, p. 158), but with the weight of powder inside the case this cord would be too flimsy. The method of transporting the cartridges is described in an extract from Baynham (1972) by sailor John Leach fighting in the American War of 1812:
'A wooden screen was placed before the entrance to the magazine, with a hole in it, through which the cartridges were passed to the boys; we received them there, and covering them with our jackets, hurried to our respective guns' (Baynham 1972, p. 102).

This extract demonstrates that the cartridge cases were held in the arms of the powder monkeys and, as an added security to ensure the powder could not be prematurely ignited, the cases were covered by their jackets. The placing of a wooden screen at the entrance of the magazine was another safety measure to reduce the potential of debris or sparks entering the magazine during action.

Spare equipment
The orlop plan of the *Duke* class shows that the gunner's store was situated at the forward end of the orlop extending across the starboard and port sides (Figure 8.38). This is consistent with the diver records that show the discovery of a partitioned compartment on the starboard side with a variety of gun equipment and small arms ammunition (Teisen 1998, p. 264). Analyses of these artefacts have demonstrated that the equipment was marked with the calibre of the gun it was intended for. The exception appears to be the coins for coining guns, which reiterates the point made in section 7.3.1 that they could be used with all sizes of guns.

Only a representative sample of stores appears to have been recovered and, from this sample, there are no spare carriage axles or trucks. The evidence from *Invincible* in section 7.4.4 identified that these heavier and bulky items were stowed in the forepeak of the hold immediately below the gunner's stores. It is possible that these components were stored there on the *St George* too.

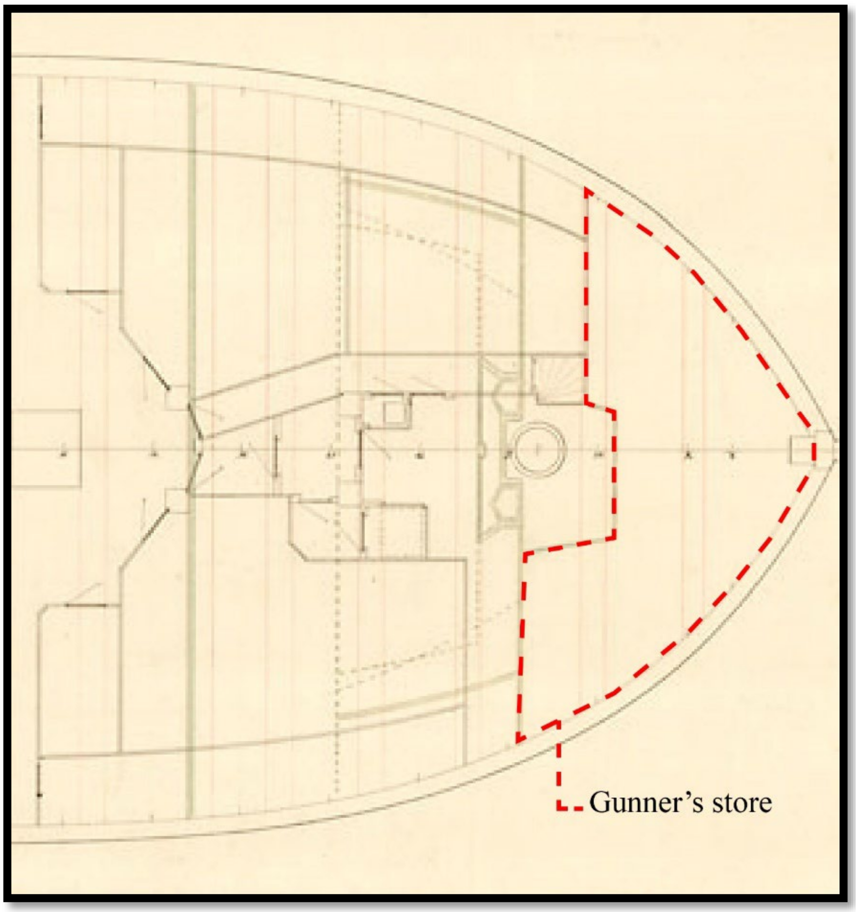

Figure 8.38: Location of the gunner's store on the orlop plan of a 98-gun *Duke* class (Image J1736 © the NMM, Greenwich, London).

8.6 KEY POINTS

The evidence presented in this chapter has identified several small technological improvements made to equipment, fixtures and fittings that led to the refinement of the gunnery system to maximise the guns' capability. These will be summarised in this section and their impact discussed and expanded on in section 9.3 and 9.4.4 of chapter 9.

1. Due to the high level of preservation of the carriages from the *St George* it has been possible to see not just how sturdy but also how well finished the carriages were. Importantly, the finishing was not just for aesthetics but served a genuine purpose to aid maintenance and increase reliability of the gun when in operation.
2. The carriages display additional fixtures for general security, to prevent malfunctions and even to ensure the gun remains operational when trucks become damaged.
3. As well as the carriages, improvements were also made to guns. For example, the Bloomfield pattern naval gun is cast with a breeching loop, which ensures the breeching stays on the gun, increasing its general reliability.
4. On *Colossus,* the additional fixture of the curved sweep piece fastened just below the port sill ensured the trucks of the carriage did not impact against the side of the hull when run out. Its curve also enabled a degree of aiming the gun fore and aft. This would have been beneficial for aiming at targets at a longer range.
5. The evidence of double shotting the guns from the *St George* confirms a preference for opening fire at very short range and to cause maximum damage with the first strike.
6. By the Napoleonic wars all guns are fitted with cannon locks, which contributes to the increase in the rate of fire and the overall efficiency of the ignition of the charge.
7. The *St George* has finally produced the physical evidence for the containerisation of shot on the gundecks, which enabled large quantities of shot to be stored there.
8. Culturally, the evidence demonstrates there was a ruthlessness to British naval gunnery. Improvements were centred around ensuring the guns remained operational even when damaged and with maximum potency. In theory, the improvements to equipment would have kept guns operational, but the guns still had to be operated by their crews. Under combat conditions it would have taken considerable discipline and professionalism to keep firing, or to hold fire to the last possible moment for

maximum accuracy and maximum damage. This did not happen overnight but instead was increasingly ingrained into the mentality of the sailors of the Royal Navy.

Chapter 9 Discussion and future work

9.1 INTRODUCTION

This chapter will discuss the key developments and general routines identified in the operation and management of the naval gunnery system that were revealed within the four results chapters. It will first establish the technological developments by addressing the changes made to the equipment that were crucial to improving the performance and operation of the guns. It will then focus on the cultural developments, i.e. the changes in ideology and behaviour, by discussing the small details on the objects, the spatial distribution of material and what that reveals in regards to changes in organisation, maintenance and operation of the gunnery system. Understanding these changes will lead into a more theoretical discussion exploring the attributes of professionalism and discipline in the Royal Navy, and whether this changes through the study period.

As seen in the work of Adams, Rönnby and Hocker in interpreting shipwreck remains, this discussion will take the technological study of the material culture from shipwrecks and stimulate theoretical thought to unravel the actions and behaviours of the people involved with the naval gunnery system, illuminating broader issues in naval society (Adams 2013, Hocker 2013, Rönnby 2013a, 2013b). This approach has allowed us, as archaeologists, to take the technological details and give them a cultural context, asking questions of why and how. This interconnection means that it is not always simple to divide the developments of the naval gunnery system into technological and cultural. Consequently, when applicable, a cultural context will also be included with a technological change.

This process has come naturally on these sites due to the incredible preservation of material, which has supported the survival of fine details such as tool and wear marks, as well as alterations and adaptations to equipment. It is these details that Hocker emphasises the importance of, as they provide the physical evidence of a technological and intellectual process that is critical in understanding the behaviour of specific individuals and groups and which opens the door to a broader understanding of society (Hocker 2013, p. 72). Through the quality and tangibility of the archaeological material presented in chapters five to eight it has been impossible not to form a connection between the objects and the individuals that left those marks and, in doing so, hypothesise the reasons behind their actions. This in turn leads one to explore the broader issues occurring in naval society and to understand how issues ashore affected those on board and, most importantly, how they dealt with it.

Studying the shipwrecks of the Royal Navy as a collective has made it possible to see clearly the improvements made to the gunnery system through refinements made to existing equipment or new inventions. It has also been possible to identify the aspects of the gunnery system that have not changed as well as those that became redundant. The shipwrecks have confirmed, or in some cases provided the only reliable dateable context for, both material and change. Of course, much has been recorded historically in contemporary texts and documents and this has been studied in conjunction with the archaeology assuring a more integrated approach (Adams 2013, p. 48).

This research has focused primarily on the gun's equipment and where it was found on the ship, and less about the actual ship design and the guns themselves. However, ship design was influenced by tactics and how to make best use of the guns. Although ship design and construction are beyond the scope of this study this research has discovered various changes in ship design that affected the gunnery system and the overall capabilities of the ship. Changes were also made in the way the ships were armed through gun establishments. These changes in establishments effected the types and number of guns ships carried. It is, therefore, important to recognise and register these changes alongside other technological and cultural developments.

Finally, the last section in this chapter will address the potential for future work by identifying where gaps in knowledge still exists and where new discoveries and archaeological investigations are needed. It will also identify the areas of research that have the potential to be further explored to enhance our understanding of specific aspects of the gunnery system.

9.2 THE SHIPS

The *London* was a product of changes in warship design that occurred two decades earlier with the design of the *Sovereign of the Seas* in 1638. The *Sovereign of the Seas* was designed with 102 guns housed on three tiers, capable of inflicting a devasting broadside. This ship was also capable of all-round fire with 10 bow chasers, 10 stern chasers and two guns capable of firing into her waist to take out any enemy marauders (Konstam 2008, p. 307). To house these chase and guns firing into the waist, the *Sovereign of the Seas* was designed with a relatively high forecastle, quarter and poop decks. The height of these decks along with the chase and guns firing into the waist indicate that there was still the intent to engage the enemy from all directions and to eventually come close enough to finish the fight by traditional boarding methods. Essentially, this was the first ship of the line but still with some design features that suited tactics from earlier times (Konstam 2008, p. 301). The tactics to make best use of the guns would not be fully recognised until the period of the first Anglo-Dutch war during the early 1650s and the introduction of the line of battle tactics (Corbett 1905, p. 95, Rodger 1996, p. 317). This was a tactic that can be attributed to both the English and Dutch: as the number of ships in the fleets increased, the tactic to make best use of all the ships was to form a line parallel to the line of the enemy and, when close enough, unleash with the guns on the broadside.

By the time of the *London* the quarter decks were reduced, and the forecastle were temporarily abandoned, they would not return to the same extent as before. The new designs of warships were centred on the capability of the broadside and less emphasis on all-round fire. Although, from contemporary drawings of the *London,* alongside the increase in armament in 1664*,* it was clearly still seen as necessary to have some capability of all-round fire. This was done by constructing several gunports at the stern and in forward-facing positions at the bow rather than having guns facing the waist.

By the last quarter of the 17th Century, we see the end of the need for separate fore and aft armament. New ships were designed to carry all the guns on the broadside but, if the need arose, to fire forward or off the stern, then guns closest could be moved from their broadside positions to the chase ports. Evidence of this can be seen from a diver's sketch of the *Stirling Castle*, which shows that the main gundeck guns on the stern port quarter are all in the broadside position. There are, therefore, two clear advantages of excluding separate chase guns, first it reduces weight, which in turn can improve the ship's sailing abilities, while also ensuring that the lower tier of guns do not lie too close to the waterline. Second, the forward and aft-most guns on the broadside are able to be manoeuvred without interference from the chase guns, which would have improved the overall operation of the guns in those positions.

Figure 9.1: Diver's sketch from 1999 showing guns in the broad side position on the port quarter (Sketch by Ted Westhead).

Included within the 1677 Establishment were two separate systems for arming ships. One for war time operations at home, when the maximum number of guns were carried, and a second for operations in war abroad and in peace abroad and at home, when a reduced number were carried. For example, the new 70-gun third-rates would only carry 62 guns during war abroad and peace abroad and at home (Endsor 2009, p. 148). Fighting abroad would require greater supplies of stores and provisions, which would add considerable weight; reducing the number of guns would balance out the increase in stores.

This system was probably the reason why the *Hazardous* was only armed with 54 guns instead of 60 and it is highly likely the third-rates lost during the Great Storm on the Goodwin Sands had 62 instead 70 guns. These examples show a definite change by the Navy not to over gun and, therefore, overweight the ships; a habit they had in the 1660s, as seen with the *London* increasing from 64 to 76 guns.

The historical record identified that the *Hazardous* was reissued with 49 of the guns the ship was captured with and a further five were added. The mixture of French and English types of shot found on the *Hazardous* demonstrates that both could be used with French guns but it may not have been possible the other way round, as English bores of equivalent guns were slightly smaller.

With the 1677 gun Establishment Pepys intended to create a standard armament for each ship and it was originally planned that each gun deck would have the same calibre of gun (TNA WO55/1650). This would improve the efficiency and effectiveness of the gunnery system. Unfortunately, there were not enough guns in store, nor the capacity to make new guns fast enough to arm the fleet in this way and the1677 Establishment was only seen as a rough guide (Caruana 1997, p. 86). As a result, many ships, including the 20 new third-rates of the 1677 ship building programme, were armed with a mixed calibre on the main gundeck consisting of 22 demi-cannon and four culverin chase guns (TNA WO55/1736). The recording of a 11ft culverin on the wreck of the *Northumberland* confirms the ship was still armed with these guns when the ship was lost in November 1703 (Pascoe Archaeology 2018b). As previously mentioned, the culverin chase guns would be positioned on the broadside until needed in the chase position. The disadvantage, however, was that the overall capability of the broadside was reduced and the management of the gunnery system was complicated by the mixed calibres on one deck.

The evidence of the culverin on the *Northumberland* and the Prince Rupert patent demi-cannon on the *Stirling Castle* demonstrates that these ships, and probably many others, still had the batteries of guns as listed from the great ordnance survey of 1696. They did not have the guns of the new 1703 Establishment, which stated that 70-gunships should have an entire battery of 24-pounders on their main gundecks (TNA WO55/1803). The gun establishments between 1677 and 1703 show that there was a clear intention to improve the efficiency of the naval gunnery system, but the lack of supplies in the ordnance stores meant that realising this reality was simply not possible.

Moving forward by 50 years and the 70-gun ships, whose heritage was firmly based in the ships of the 1677 shipbuilding programme, were about to become rapidly inadequate against a new breed of warship. On the 5th May 1747 Anson and his fleet captured for Britain and the Royal Navy a vessel that was the cutting edge of ship technology. The *Invincible* was a new type of 74-gun ship, a type that became the future of warship design for Britain and indeed all the most powerful navies in the world. The impact of this type of warship can be measured by the fact they dominated major fleet battles. For example at the Battle of the Nile 13 out of 14 of Nelson's fleet were 74s and over 50% of all the ships at the Battle of Trafalgar in 1805 were a 74 (Wilson 2014, p. 323); its lineage began with the *Invincible.*

The introduction of the 74-gun ship was key to the development and success of the Royal Navy. This type of vessel provided a swift, manoeuvrable and stable gun platform, fundamental qualities of an effective gunnery system, which had been lacking in many British designs during the first half of the century. When discussing technological developments regarding the *Invincible* and gunnery, one must therefore begin with the ship itself, as the ship provides the foundation for the naval gunnery system; the ship is the ultimate artefact.

When Anson captured the *Invincible* British naval ship design was stagnating in a rigid system of building Establishments. The aim of Establishments was to create uniformity in the building of every rate of ship and ease supply issues by standardising sizes of equipment and stores (Baugh 1977, p. 199). These Establishments tended to favour conservatism over more innovative ideas in design (Baugh 1977, p. 199). The British appeared to be obsessed with building three-deckers of 100-80 guns or two-deckers of 70-50 guns. The larger ships of the two types, with the greatest number of guns, such as the 100-gun three-decker and the 70-gun two-decker were the far better ships (Lavery 1991, pp. 9–10). The three-decker 80s, however, were the worst ships ever built, being far too top heavy for their length and therefore unstable, poor sailers (Baugh 1977, p. 195, Lavery 1991, p. 10). The British would later learn, through the capture of *Invincible* and others like her, that it was far better to have a smaller number of heavier guns than a greater number of lighter guns. For example, a British officer noted that the overall discharge of British 80-gun ships was 1,312 pounds but a French 74-gun ship could discharge 1,705 pounds of shot (Lavery 1991, p. 10). If one-on-one this would have given French ships a considerable advantage.

The French realised during the second half of the 18th Century that they could no longer compete with the British Navy in numbers. Instead they focused on designing individual ships to be at the forefront of ship design, and so evolved the 74-gun ship (Lavery 1988, p. 3, 1991, p. 10, Rodger 2005, p. 409). The French designers focused on reducing weight higher up and, as a result, increased the length of the hulls of their two-decker's, allowing a greater number of heavier guns to be carried on the two main gundecks (Lavery 1988, p. 3, 1991, p.

19). The length of *Invincible's* gundeck was 171 feet and three inches and the breadth was 48 feet 11 inches (NMM/POR/D/9), whereas an 80-gun ship of the 1745 establishment was only 165 feet on the gun deck and a breadth of 47 feet (Lavery 1983, p. 173). The greater length and reduction in height increased stability and, along with better hull designs, gave these vessels superior sailing and fighting capabilities.

When the *Invincible* was surveyed at Portsmouth Dockyard following her capture, the lower gunports were found to be six feet two ¾ inches above the waterline (NMM/POR/D/9). This was at least two feet more than most 80 and 90-gun British warships, which were mainly only 3-4 feet above the water line (Bingeman 2010, p. 12). This was extremely significant when in action, especially during rough sea conditions, as the *Invincible* could have had the ports of her lower tier open and therefore the heaviest guns at the ready but the British ships would have had to be closed (Baugh 1977, p. 197). Essentially, French ships were larger, longer and carried their main armament better that the British ships (Baugh 1977, p. 198). Larger hulls also meant larger holds and therefore storage capacity, which in turn meant time at sea could be increased. The 74 was an ideal general-purpose ship with good sailing qualities, a heavy broadside and the ability to stay at sea for long periods of time; the *Invincible* was capable of carrying supplies and stores for eight month long operations (Lavery 1988, p. 13).

Despite the superior design of the French 74s and the obvious advantages at sea, it took another decade for the British to develop their own 74s. This occurred through the persistence of Anson—who, by 1751, became the First Lord of the Admiralty—and the introduction in 1755 of a pair of young and innovative Surveyors of the Navy: Thomas Slade and William Bately. It was from this moment that the design of *Invincible* really began to influence British shipbuilding. Although with the exception of two copies, the *Valiant* and the *Triumph,* the British designed their 74s in a typically British way: strong, and therefore built to fight, and also capable of staying at sea for even longer periods (Rodger 2005, pp. 414–415).

The adoption and adaptation of this French design enabled the ships of the Royal Navy to fight all over the world and for extended periods (Rodger 1996, p. 418). With increased stability and more accessible fire power, these ships had the whole arsenal at the ready and the strength of shot to compete with all types of ships of the line. This is evident from the Battle of Trafalgar when several British 74s found themselves fighting with success against larger French and Spanish ships (Adkins 2005).

9.3 TECHNOLOGICAL DEVELOPMENTS

This section will focus on the changes in the equipment necessary for working the guns and the discussion will follow the same themes as laid out in each of the results chapters.

9.3.1 *Mounting the guns*

The *Mary Rose* has shown that the English developed the four wheeled carriage for mounting the SBML gun relatively early compared to other naval powers. It was more suitable for use on board ship than the two wheeled variety, which was used by other European naval powers up to the end of the 16th Century, evident from the carriages found on the Swedish warship, *Mars*, the Spanish Armada wrecks of 1588 and the Spanish galleon *Santiago de Galcia*. The inefficiency of the four solid wheels against the deck combined with its relatively compact design meant it was easier to control and allowed greater space to reload from inside the hull. As ship design changed to accommodate and make better use of the SBML gun, during the latter half of the 16th century, so did the design and construction of the carriage.

Evidence from the *London* demonstrates that the English had improved upon the four wheeled carriage found on the *Mary Rose* by developing a more uniform design that was robust, compact and even more manageable in the confined spaces of the gundecks (Figure 9.2). It was known as the truck carriage and was normally fitted with four trucks or, when used to mount a drake like those from the Duart Point wreck and from Windsor Castle, the rear trucks were replaced by solid pieces of timber to negate the lively recoil of the gun (Figure 9.2). Its lineage, however, is still recognisable from those early examples found on the *Mary Rose*. The earliest archaeological evidence of this later style of truck carriage can be traced back to the 1590s with the evidence from the Alderney wreck (Monaghan and Bound 2001, p. 50), but it is highly likely that it was in use even earlier. The carriage recovered from the wreck of *Stirling Castle,* lost in 1703, shows how the design of the carriage had not changed over a period of over 100 years (Figure 9.2).

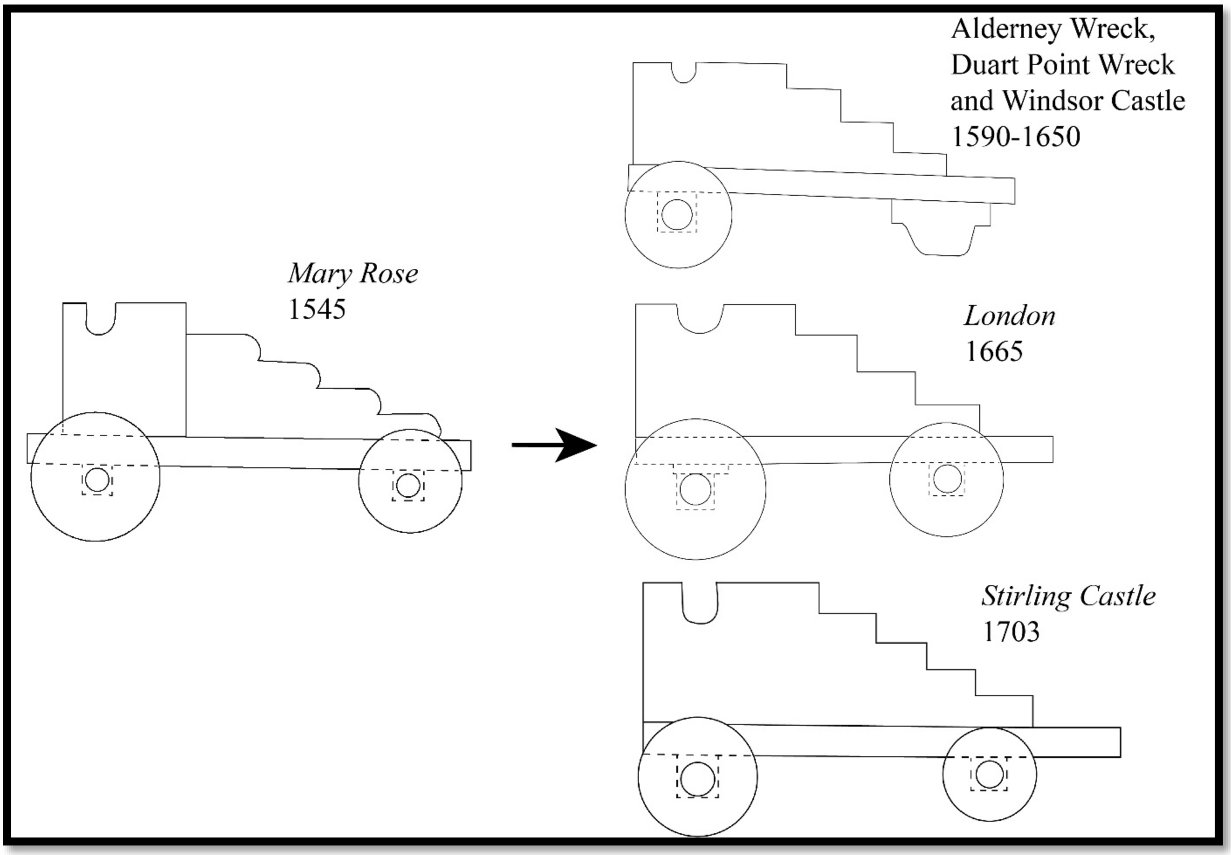

Figure 9.2: Showing the evolution of the English truck carriage from real examples found on shipwrecks and terrestrial collections. The drawing of the *Mary Rose* carriage is based on example **81A3003/2** (Hildred 2011, p. 53), the chock carriage is based on the Windsor castle example (Smith 2001) and the *Stirling Castle* carriage is based on McElvogue's drawing (McElvogue 2008). (Diagram produced by author from original drawings but not to scale).

The *London* carriage, however, stands out, not because it is a different type or design but because it was adapted to mount a non-standard 24-pounder, which was a narrower and longer gun than the one it was originally made for (Pascoe 2017b, p. 47). The small details of the *London* carriage (Figures 5.10, 5.13 and 5.15) have provided an incredible insight into everyday problems the crew on board had to deal with, as well as the broader issues in the management of the navy. The historical record has identified that the *London* was issued with an extravagant selection of guns that did not conform to the required standard (Fox 2011) and the evidence from the recovered guns from the site has shown the variabilities in size between guns of the same calibre (Fox 2011, Pascoe 2017b). This would have made issuing the ship with carriages of the correct size more challenging. Francis Povey writing in 1702 describes how the gunner must not assume the carriages will fit all the guns issued to the ship and therefore the gunner would have to adapt the carriage to fit the gun (Povey 1702, pp. 12–13). This demonstrates that issuing ships with standard guns was still a problem by the early 18th century, despite Pepys's efforts to standardise the arming of all ships in the fleet as early as 1677. It also suggests that alterations made to the *London* carriage could have occurred after the guns and carriages came aboard and was therefore potentially carried out by either the Master Gunner or by the carpenters, under the direction of the Master Gunner. This indicates that the crew were having to improvise and adapt on the job, and therefore reacting challenges caused by broader issues in the navy. This is one example of shipboard culture being reactive.

When looking closely at the alterations made to the *London's* carriage, they were neat and well crafted, but they were obviously a temporary fix. An appropriately sized carriage would have been more reliable and durable, especially important during wartime duties when the guns are likely to be used frequently. The guns on board the *London* had been its armament since 1664 and the fact that this carriage was on the *London* when it blew up in 1665 demonstrates a lack of awareness and forward thinking on either the part of those on the ship, those ashore with the management of stores, or both. One would think after a year in service word would have got back to shore for the replacement of bodged equipment and the carriage would have been replaced when back in dry dock on the 20th February 1665. The fact that it wasn't identifies one problem in the management of the gunnery system. One could argue that the reason the carriage was not replaced was that the crew found the alterations to be adequate. The Chatham ledger, however, identified that none of the 24-pounder shot were fired during the penultimate command of the ship, and therefore the gun mounted on this carriage was not operated.

The complete lack of use of the gun shows that the alterations made to the carriage were not tested under the stresses of live firing. This creates two issues, first it doesn't bring attention to any potential weaknesses of the carriage and, second, no one would have known how reliably it would have performed during action. This perhaps explains why the carriage was not replaced as the Master Gunner was not aware of any potential issues. Fault should not be entirely placed on those on board as the storekeepers and mangers at the dockyard would have been aware, through the Chatham ledger, what equipment went onto the ship. They would have known that the *London* was issued with several non-standard guns as well as guns of various ages and origins, which would have varied in size. If one was thinking ahead and being proactive then suitable carriages would have been made in advance of the ship returning to Chatham in February 1665. Instead, the *London* was probably equipped with several carriages that had been adapted, eight of which were for the main gundeck 24-pounders that were not tested during the ships1664-1665 command.

One other detail that was visible on the *London* carriage was the relieving or compression marks on the inside of the first step just behind the trunnion recess (Pascoe 2017b, p. 38). This was made to accommodate the re-enforcing rings on the gun. This could have been for the previous gun as the additional planks on the inside of the cheeks have shown that the final gun was narrower than the previous. The relieving is a sign of a general lack of precision when marrying guns with carriages. This reiterates the problem that there were large numbers of guns in circulation that were of non-standard design, aging and of various origins, making it impossible to produce matching equipment with any sort of precision.

The issues with the *London's* carriage highlight one problem with the naval administration at this time with their lack of ability to supply the appropriate guns for arming individual ships in the fleet. It demonstrates how the lack of standardisation of the guns effected the rest of the gunnery system and those operating it on board ship, and this will become further evident during this section. It also shows why standardisation was sought after by Pepys as it would make the overall management of all aspects of the navy more efficient and effective. Echoing Hocker's point (Hocker 2013, pp. 72–96), it is the detail recorded on the *London's* carriage that reveal the behaviours and actions of the individuals directly involved in the operation and maintenance of the gunnery system. This then encourages one to think about the broader issues in the naval administration that were causing these problems on board ship.

Moving forward 41 years to the *Hazardous* and those maintaining the gunnery equipment are still in the habit of adapting existing carriages. With the case of the *Hazardous* this was not to suit the guns, as they were the appropriate guns for those carriages, but it was to convert the French carriages to match the English method of breeching the gun. Section 6.3.1 has shown that this was done by adding ring bolts to the sides of the carriage, leaving the breeching holes in the side of the cheek redundant. The carriages and axles recorded on the *Hazardous* and the carriage recovered from the wreck of *La Belle* show that the French had designed their carriages with interlocking joints between the underside of the bed and the top of the axles. They also included a transom timber at the front of the carriage between the inside of the cheeks. These would have added strength and greater stability to the carriages. The transom becomes a feature of the English carriage from at least 1721 (RAIms in Lavery 1987,

p. 282) and joints became features of the new pattern English transom carriage from *c.* 1725 onwards (Lavery 1987, p. 129, Caruana 1997, pp. 367–78). These features may well have been influenced by the capture and reuse of French carriages such as the ones found on the *Hazardous*.

The English truck carriage in its unaltered form, and married with an appropriate gun, was successful as it served a purpose for approximately 150 years. We have, however, learned that it had its faults, which were addressed with the introduction of the transom carriage *c.* 1725 (Figure 9.3). The old carriage was prone to trapping moisture between the bed and cheeks, causing rot to set in (Moody 1952, p. 305). The solid timber bed was no longer seen as necessary and instead the axles were made more robustly with joints, which coincided with joints on the underside of the cheeks. These interlocking joints added strength and durability, and the loss of the bed solved the issue of rot, reduced weight and saved timber (Caruana 1997). The greater breadth of the rear axle accommodated the placement of the stool bed and coins and therefore enabled the support of the breech of the gun. Further weight was reduced by cutting an arch into the lower edge of the cheeks (Moody 1952, p. 306), which also allowed better access to the ends of the fixing bolts (Caruana 1997, p. 368). The removal of the bed meant one fewer component that could potentially break, so this type of carriage would be quicker and easier to repair.

The evidence from the spare axles on *Invincible* and the carriage parts recovered from Woolwich show that the components were labelled with the type of gun they were intended for. This demonstrates they were made to a standard size and therefore with greater precision. This was made possible through the standardisation of the guns. If the size of the guns were known, then equipment can be mass-produced to suit. The dimensions of carriages for all calibre of guns was documented from at least as early as 1721 (RSIms in Lavery 1987, p. 292) and thereafter with the introduction of a new pattern. The standardisation of parts makes it much easier for maintaining the carriages on board ship when making repairs. If replacement components are already made to the correct size, then they can be used to swap out with damaged ones like-for-like. This is another example of how the gunnery system was becoming more efficient at both the manufacturing stage and on board ship.

The spare axles on *Invincible*, however, were not completely ready for use. Evidence from contemporary drawings, as well as the *Royal George* carriage and carriage parts from

Woolwich, show that the joints on the underside of the cheeks slotted into joints on the upper side of the axles. These joints were not present on *Invincible's* spare axles (Figure 9.3). This is the type of detail missing from contemporary drawings and descriptions of carriages and one would also not be aware of this practice from the study of complete carriages or reused carriage parts from the archaeological record. The unfinished spare axles demonstrate that there were still minor differences in individual carriages that would have had to be addressed when fitting the new components. The cutting of the joints was therefore left until the axle could be offered up to the cheek of the carriage. This is an example that highlights Adams' point that combining archaeological and historical source material provides new insights and leads to a greater understanding than if the two categories of source material remain discreet (Adams 2013, p. 48).

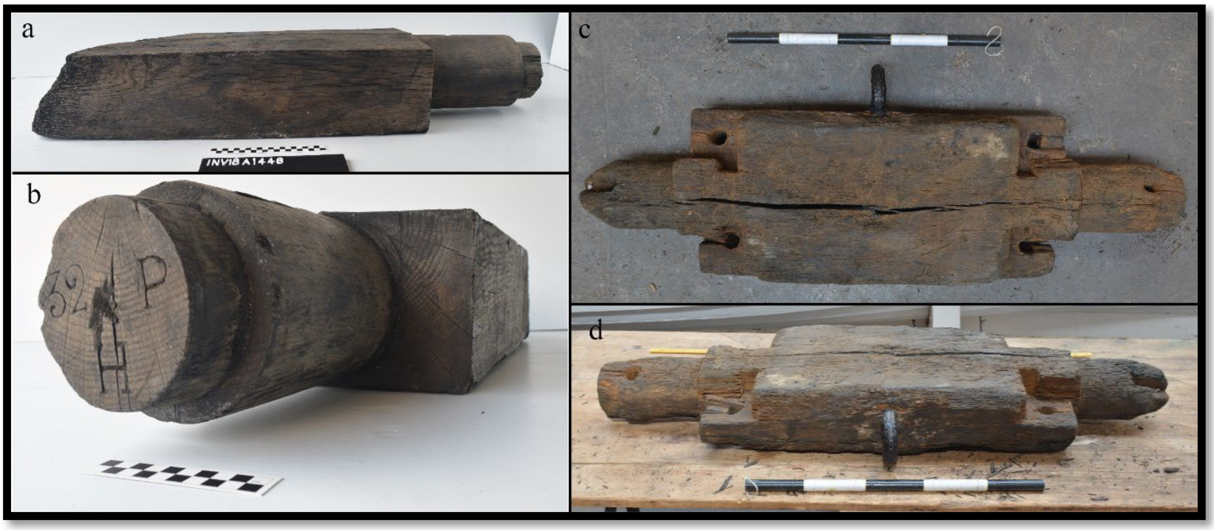

Figure 9.3: Images a and b showing spare unfinished hind axle from Invincible and images c and d showing used hind axle with joints from Woolwich collection (Photos by author).

The evidence from the *St George* has shown that the navy continued to tinker with the design of the carriage to improve performance, durability and reliability (Figure 9.4). Some modifications also coincided with new fixtures added to the inside of the hull structure, which was visible on the structure of the *Colossus* and presented in section 8.4.5. Many of the carriage details were shown on contemporary plans and drawings of carriages, such as Congreve's illustrations shown in Figure 8.10, and historians Lavery and Caruana have reproduced copies of the drawings of the different patterns of carriages since 1725 (Lavery 1987, p. 129, 2009, p. 85, Caruana 1997, pp. 367–78). These were extremely useful for identifying the different features present on the *St George* carriages and understanding when they were introduced. It is, however, the carriages themselves that enable a deeper level of analysis and provide insight into those who designed, built and used them. With the opportunity to look closely and to touch the carriages you begin to fully appreciate the craftsmanship that went into their construction and the rationale behind the details. The counter sunk and riveted bolts and chamfered edges was not simply for aesthetics, it served a genuine purpose. When in operation the guns are moving, either by the crew pulling on tackle to run the guns out or recoiling when the gun is fired. During these actions the ropes and breeching are rubbing against the carriage, so it was important that there were no sharp edges to cause a snag or chafe, which could lead to a malfunction. If the carriage needed to be traversed or the gun elevated, heavy tools such as crow bars and hand crow leavers were used. The chamfered edges also reduced the chances of the timber splitting when robust equipment was used to manoeuvre the carriages or if other heavy objects struck the carriage. A small split could eventually lead to a larger break, which could potentially render the gun out of use until the damage to the carriage was repaired. The chamfering to an angle of 45 degrees was, according to Caruana, a specific characteristic of the 1791 carriage pattern (Caruana 1997, p. 379) (Figure 9.4). The fact that these small details were being documented is further evidence of the navy ensuring standards were followed.

As well as the fine but robust construction of the carriages there were several extra components added. First, there was the additional ironwork such as the front axle brackets and iron plates on the lower face of the rear axle. These would have added strength and support and therefore increased the longevity of the carriage, which was under considerable strain from the weight and motion of the gun when fired. The force used to run the gun out, along with the weight and momentum of the gun, would have caused the front of the carriage and possibly the trucks to impact heavily against the inside of the hull. This led to the introduction of the breast piece to the front of the carriage, introduced on the 1795 pattern carriages (Caruana 1997, p. 379) (Figure 9.4). The evidence of fixing holes on the front face of the cheeks demonstrated that the *St George's* carriages were fitted with these. The breast piece would have also increased the longevity of the carriage by reducing the impact on the more vulnerable trucks. It also served to stop the front trucks from deviating the flow of unwanted water flowing down the channel along the sides of the deck.

On the sides of each cheek above the front trucks the preventer cleat was fastened (Figure 9.4). This served to stop the gun tackle and breeching rope getting tangled in the front trucks when the gun recoiled (Caruana 1997, p. 379). Finally, the fighting block was added to underside of the front axle, so if a truck was damaged or came clean off, the carriage remained in an upright position and was still able to function (Figure 9.4). All of these additions either functioned to prevent a fault or to keep the gun operational even when damaged. These small developments with the carriage have derived from the experience of those that were operating the guns, who have developed ways to improve their capability and reliability.

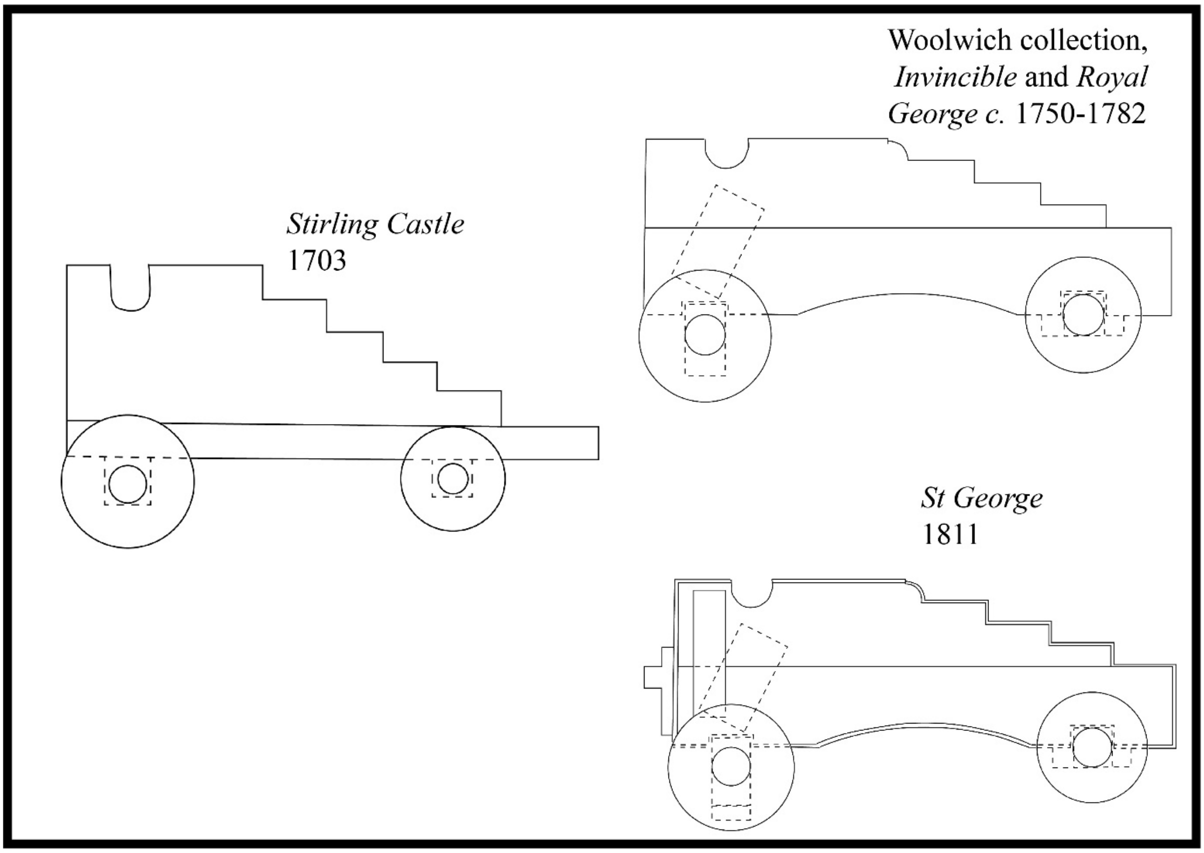

Figure 9.4: Evolution of the English/British gun carriage from truck carriage to transom carriage based on 18th and early 19th century archaeological evidence. The illustration only includes the wooden components of the carriages and drawings are not to scale. (The author produced the drawings from a combination of original drawings (*Stirling Castle* carriage based on McElvogue drawing (McElvogue 2008)), photogrammetry models and photographs).

The archaeological evidence from the *Invincible* through to the *St George* shows that there was greater precision in the manufacture of the gun carriages, which was a result of the standardisation of the guns. The makers of carriages or the crew on board ship no longer had to improvise and adapt carriages to fit the sizes of guns because the sizes and designs of carriages were officially documented to fit standard calibres. This makes managing the whole gunnery system simpler and more efficient.

One other accessory was the coin for changing the elevation of the gun. This very simple wedged shape design has changed little from the examples found on the *Mary Rose* through to the ones recovered from the *Invincible*. None were found on the *Colossus* or the *St George* but there is nothing to suggest they would have changed. When the transom carriage replaced the truck carriage with a solid bed the stool-bed was introduced to provide a platform for the coin to rest on and the ordnance inventories have identified that each gun was issued with one each. By the mid-18th century an additional type was introduced known as the coin for coining guns and the *Invincible* and *St George* have potentially provided the evidence for these. Section 8.4.1 has put forward several suggestions for its use, but it is still far from clear. For now, perhaps the most plausible interpretation is for depressing the gun to point at a target low down at close range. This is another example of the navy trying to increase the effectiveness of the gun and, like the addition of the sweep piece (section 8.4.5), provide a method for altering the arc of fire.

9.3.2 *Securing and manoeuvring the guns*

Due to the weight of the gun, the extreme forces created when the gun was fired, along with the movement of the ship, the gun's security was paramount for both the safety of the crew and the ship, as well as the performance of the gun. This research has shown that there were an array of different components and equipment for securing and manoeuvring the guns and, since the adoption of the SBML with the four wheeled carriage, these accessories remained remarkably similar with only minor alterations or additions. Although the equipment may have not changed significantly, the way it was used by the crew did and this was influenced by changes in ship design and tactics.

Following the *Mary Rose,* ship design becomes progressively more focused around the guns and on allowing more space on the deck for them to operate. With greater space the guns had the room to recoil into a position where the crew could then reload the guns without having to either unfasten it from the side of the hull and pull back, or shuffle down the barrel outside the ship. To enable inboard loading the gun needed secure fastenings on the inside of the hull and carriage to attach a breeching rope, with just enough slack to halt the gun in the correct position, and for the attachment of gun and train tackle, to either move the gun forward or hold its position.

The *London* has provided the earliest and the richest evidence since the *Mary Rose* of much of this equipment and of how it was used, alongside the fixtures and fittings on the hull and carriage, to enable the gun to be reloaded inboard and then run out again to fire. The equipment that was necessary for securing and manoeuvring the guns in this fashion were the breeching rope, gun tackles and the hand crow leavers, the latter for moving the carriage from side to side. The comparison with other sites documented in this research shows that these pieces of equipment do not change. Instead it is the greater number of crew and their ability to operate the gun that is the difference, and which will be discussed in section 9.4.

Of course, most time at sea was spent in transit with the guns housed inboard but still loaded in preparation for a swift action. The combined archaeological evidence from the later wrecks of the *Stirling Castle, Hazardous, Invincible* and *Colossus* also identifies the methods for securing the guns when not in use. The advantage of studying several shipwrecks over an extended period is that it makes it possible to ascertain the variations in methods that differed depending on the particular location and space available for the gun, and the activity or conditions the ship had encountered when it was lost. It is clear that there were several methods of securing the guns and it is highly likely these methods were not restricted to one period but were common throughout.

The *Hazardous* and the *Stirling Castle* have demonstrated that there were at least two methods of securing the guns while in transit. From looking at the orientation of the guns on the *Stirling Castle,* along with the details from the recovered gun, the general practice was to elevate and secure the muzzle of the gun above the port, and the wear marks above the port on *Colossus,* alongside contemporary illustrations, show this procedure continued throughout the SBML era. Where there was less space for the gun when run in, the gun was turned alongside the gunport and lashed at the muzzle and breech ends.

9.3.3 *Loading*

This section will discuss the equipment used in the operation of loading the gun, which is presented in chapters five to eight. This includes the sponge and rammer, ladle and wads. There was one other tool, the worm, which was a curly iron prong on the end of a wooden stave, used to remove the accumulation of powder charges at the end of the chamber. The worm has not survived well in the archaeological record, due to the iron part corroding, and has not been found in any of the case study's assemblages.

Sponge and Rammer

The introduction of new fighting tactics influenced changes in ship design and the way the guns were operated. Developments in the types and form of the gun's equipment is a useful indicator of changes in the way the guns were operated. Before the line of battle, during the first quarter of the 17th century, ship's fighting instructions recommended first engaging the enemy with the forward chase guns, followed by a broadside. Next, to give the crew time to reload, the ship would turn to engage the stern chase guns before turning again to engage the other broad side (Rodger 1996, p. 307, Konstam 2008, p. 302). The process of loading was obviously quite slow, and the preferred type of loading equipment, the staved rammer and sponge, meant that the loader was partly exposed at the muzzle of the gun when reloading. This was because the loader would have to pass the long stave out the gunport first, before being able to push it back down the chase of the gun. To protect the gun crew the ship was turned away from the action, allowing the gun crew's protection to reload their guns (Rodger 1996, p. 307, Konstam 2008, p. 302). The line of battle tactics, however, would have meant all ships in the fleet had to remain in a formation and, as a result, would have to fire multiple broadsides from the same side (Rodger 1996, p. 317). As a result, there was no protection for the gun crew other than the side of the hull. The ability to load the guns entirely from inside the ship would have been much safer, but to do this would need the general adoption of the flexible sponge and rammer, known as the rope sponge.

The first use of the rope sponge pre-dates the line of battle tactics as it is described by Sir Henry Mainwaring in his seaman's dictionary from the early 1620s. His description also suggests the staff or staved variety was more common:
'*The sponge of a piece of ordnance is that which makes it clean. They are commonly sheep-skins put at the end of a staff.....;but we have it also fitted to the ends of a stiff rope, so is the rammer also, to sponge and lade within board.'* (Mainwaring, G. E. and Perrin 1921, pp. 231–232)

Also worthy of note is that he explicitly states that the rope variety allows for the action of ramming and sponging to occur inboard, which could be seen to suggest that the staffed versions does not. According to the ordnance stores for several of his Majesty's ships from

1609 all the loading equipment was listed as staved (TNA WO55/1675). At some point between 1609 and 1620 the rope sponge was introduced. The English appear to have introduced the rope sponge earlier than other countries. For example, the evidence from the Swedish warship, *Vasa*, which sank in 1628 identified that the loading equipment was all of the staved variety (Padfield 1973, p. 60, Cederland 2006, pp. 345–349). Space was available on the *Vasa's* main gundecks to at least load the gun from inside, but due to the length of the staved rammers the loaders would still have had to pass the rammers and sponges out the port, thus partly exposing themselves to danger. On the quarter deck there was no option of loading inboard. The narrowing of the deck and the length of the guns would have meant the loaders would have had to venture out onto the chainwales, outside the ship, exposing themselves to enemy fire to load the guns (Hocker 2015, p. 111). Although the *Vasa* was equipped to fight with the gun as the primary weapon, the gun was not utilised in that way. Instead, Swedish tactics were still in the old mindset of boarding the enemy ship and fighting with hand weapons to gain control (Hocker 2015, p. 63), a practice was common to all the continental navies (Corbett 1905, p. 51). The great guns were used in the early engagement (Hocker 2015, p. 63) and this is probably why the Swedish navy were not adopting the use of the rope sponge and rammer.

Although the rope sponge was introduced to the gun's accessories, the use of the rammer and sponge on the end of a solid stave would appear to be the preferred implement, at least up until the mid-17th century. An inventory of ordnance and stores for His Majesties' ships from 1646 shows that the rammer and sponges (referred to as heads and rammers) were generally equal to or more than the number of guns, and the number of rope sponges was just under the number of guns. An example of this is from the 33-gun *Adventure,* which was supplied with 36 pairs of heads and rammers and only 30 rope sponges (TNA WO55/1648). Using a staved rammer and sponge was probably more efficient when you had time and room to use it, but under fire the use of the rope sponge would have enabled you to perform the loading of the gun from back inside the safety of the hull.

We can see from the Chatham ledger that the *London* was issued with as many rope sponges as the number of guns. The staved variety was shared between several guns (TNA WO55/1667), which clearly demonstrates that during times of action it is the rope sponge that was used. The increased regularity of naval actions during the Anglo-Dutch wars undoubtedly contributed to changes in tactics, which in turn changed the way the guns were operated. The tactics led to fleets engaging for sustained periods of time, involving multiple broadsides before disengaging. Being able to load the guns completely inside the hull would have been an absolutely necessity and the rope sponge allowed the gun crews to do that. The use of the rope sponge would allow the gunport lid to be closed, which may not give much protection against a direct hit from a cannon shot, but, as Povey states in his 1702 publication, it would allow protection from small arms fire (Povey 1702, p. 44). The closing of the port may have also had psychological benefits, much like the blinkers attached to a horse's bridle: ignorance is bliss.

The *London* has provided the earliest English evidence for rope sponges, an essential piece of equipment that became the primary equipment for loading up until the early 19th Century. The sponge head recovered from the *London* appeared to be fairly innocuous at first, but alongside a greater understanding of mid-17th century gun types and the arming of ships with guns that included those with tapered bores, it becomes apparent that a conical shaped sponge head was necessary to reach the very back of the chamber (Figure 9.5). Without such a design it could have been fatal for the loader who had to ram home the next charge. It is these small but essential design details that are not present in contemporary historical documents and inventories and which only the archaeology can provide.

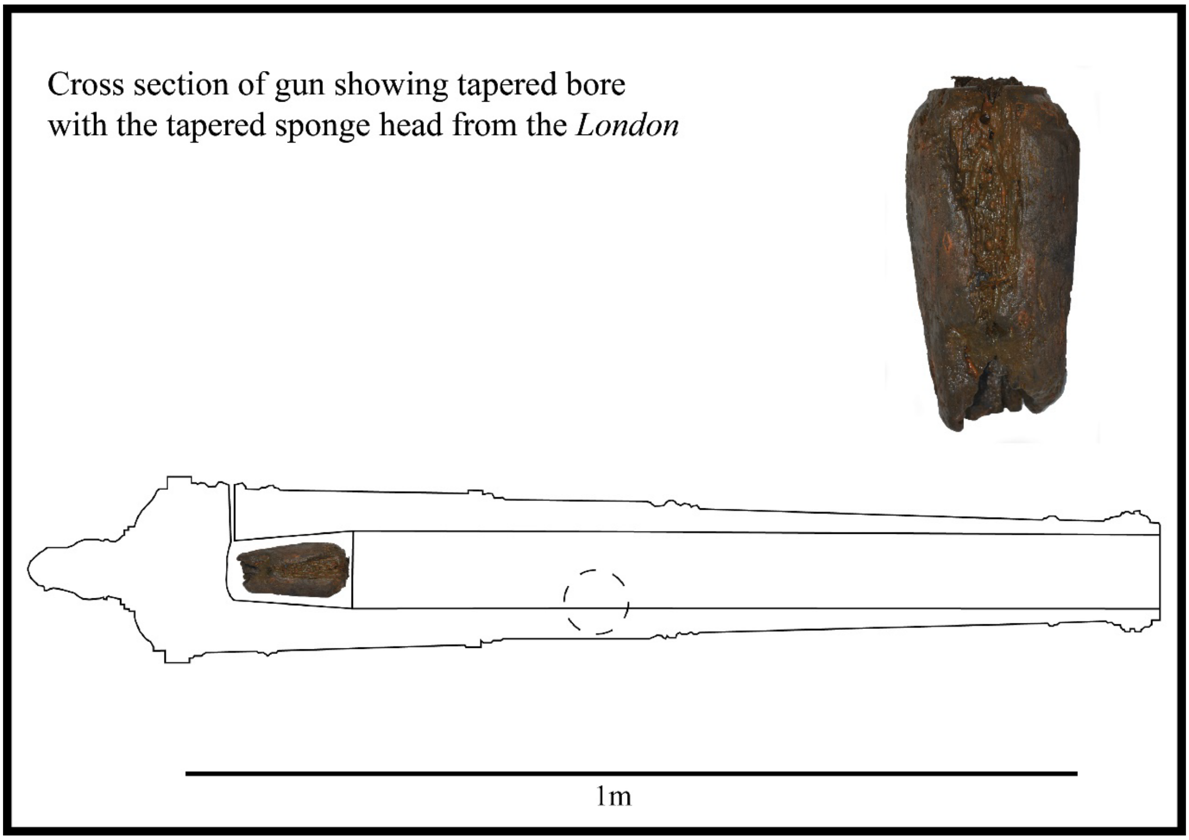

Figure 9.5: Showing cross section of gun with tapered bore and tapered sponge. The gun illustration is based on the minion drake from the Duart Point wreck (Martin 2017, p. 143). (Diagram produced by author).

The loading equipment from the *London* shows that by at least 1665 the navy had a simple but distinctive style and the examples recovered from the *Hazardous* show that by 1706 it had not changed. Jump forward to 1758 and the *Invincible* shows there was a change in design of both the rammer and sponge head (Figures 9.6-7). As we have seen from the *London* sponge head, and which will be apparent from other changes in equipment later, the navy appear to change things for a functional purpose not merely for style. The change to a plain wooden cylinder for attaching the sheepskin sponge is understandable as all that was required was a surface to cover, but the change in rammer form is not so clear. The simpler cylinder type would have been quick and easy to produce and would therefore speed up production. Although there was a distinctive style of rammer head between at least 1665 and 1706 its classic cone shape had not changed since 1545 and the time of the *Mary Rose* (Figure 9.6). This indicates that it must have functioned reasonably successfully in that form, as it served the purpose for at least 160 years. Then, at some point between 1706 and 1758, the navy changed the design quite markedly by introducing a deep recess above the shoulder and adding a neck at the top (Figure 9.6).

This research has yet to find any official written rationale for this change but offers two possible explanations. First, it has been established when firing the gun that deposits, from a combination of partially combusted powder charge material and wadding, build up inside the barrel. Some of these deposits will be removed by the sponge and larger deposits by the worm. It is likely, especially with repetitive fire, that some deposits got left behind and could have gotten trapped between the sides of the rammer and the inside of the barrel, making it harder to push and draw the rammer in and out. With the introduction of a deep recess any residue left on the inside of the barrel falls into the recess when the rammer moves up and down, rather than clogging up around the side of the rammer. This new design potentially made it easier and more efficient to use. The other noticeable change is that the calibre of the gun is engraved on the top surface of the neck, a surface that does not come into contact with the shot or barrel or get clogged by residue; the calibre can always be clearly read. The second, much simpler explanation, is therefore that that the manufacturers designed a rammer that could be easily labelled and mass produced to standard sizes.

By 1811 there appears to be no change in the design of the rammer head from the evidence of those recovered from the *St George.* However, the two 12-pounder rammers of the staved variety had extremely worn edges, suggesting regular use. This was unusual as the flexible rammer and sponge, according to the inventories, was the type issued to all guns. The 12-pounders were either located on the upper deck, which was partially open, or on the forecastle, which was fully open. One possible explanation for their use is that there were no obstructions from above combined with slightly shorter guns: 9-8 ½ feet as opposed to 9 ½ feet long for the 32 and 24-pounder guns on the lower and middle gundeck (Caruana 1997, p. 272). There was therefore greater room to wield the staved rammer and sponge on the upper and forecastle decks. This potentially identifies that the solid staved rammer and sponge was preferred over the flexible variety when there was opportunity to use either.

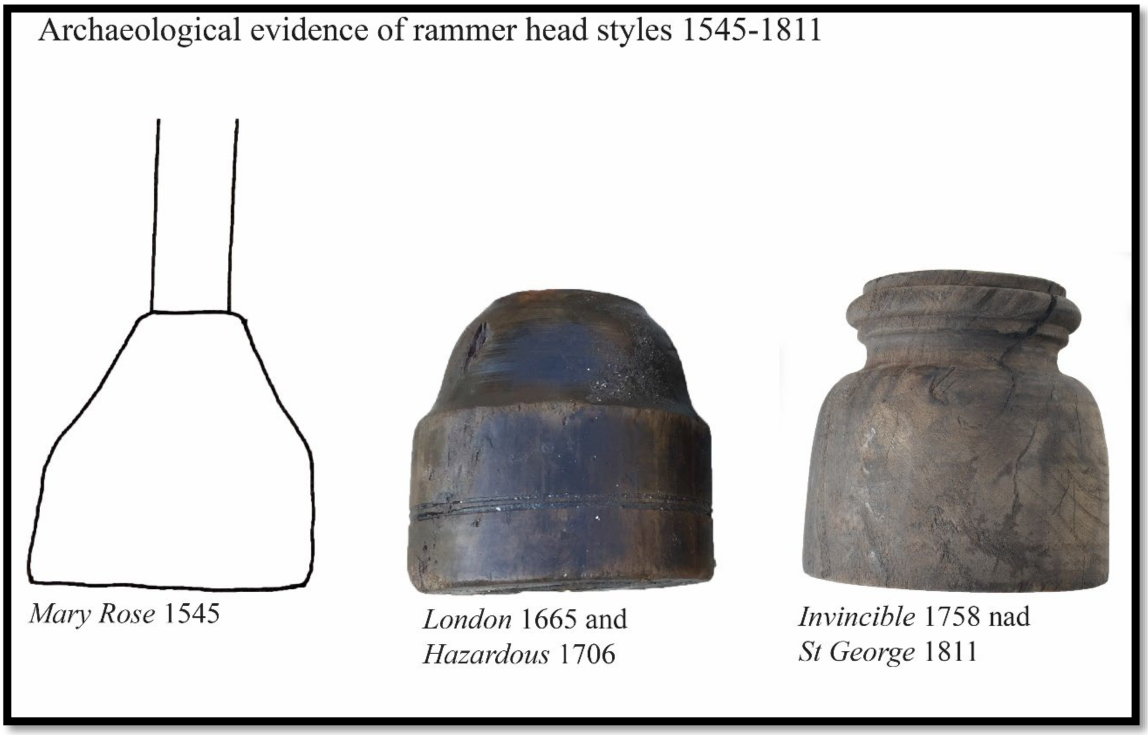

Figure 9.6: Showing the evolution of the rammer head from the time of the *Mary Rose* in 1545 to the *St George* in 1811. The *Mary Rose* rammer is based on a drawing of example **80A1416** (Hildred 2011, p. 458). (Diagram produced by author).

The *St George* has also identified a minor change again in the design of the sponge cylinder, which was formally documented in 1794 (TNA ADM160/150) (Figure 9.7).

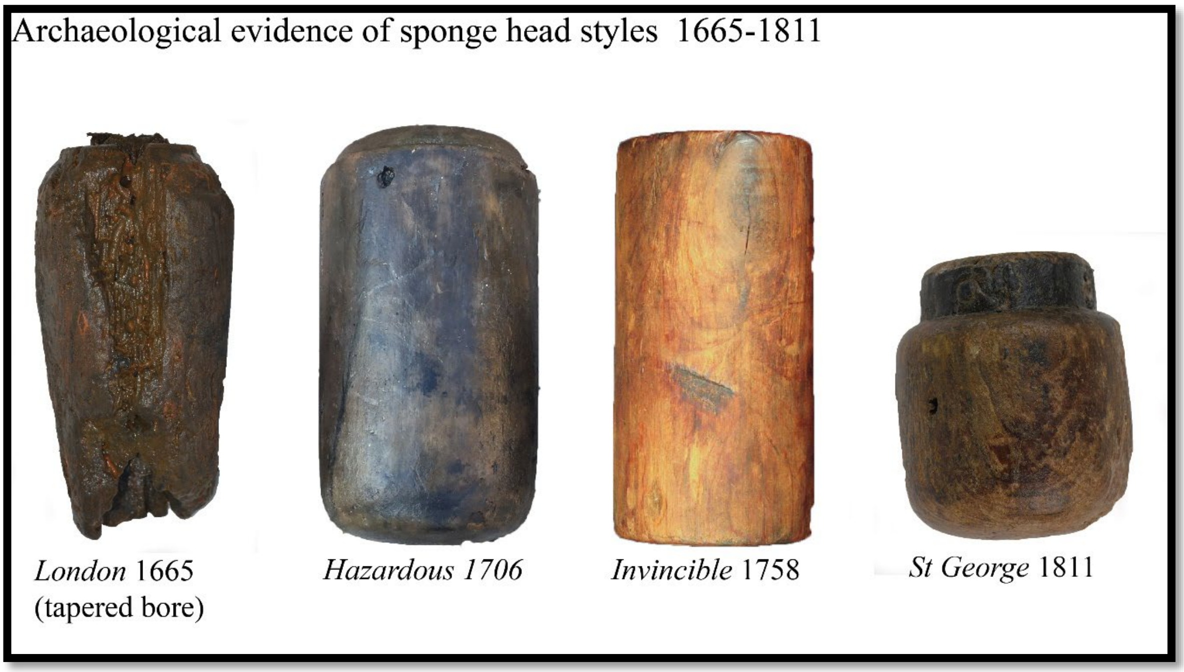

Figure 9.7: Showing evolution of the sponge head from the *London* 1665 to the *St George* 1811 (Diagram produced by author)

Wadding
Essential in the loading process was the wadding as this kept the charge and shot sealed and contained at the chamber end of the gun. Archaeological evidence has shown that from at least the period of the *London* up until 1811 and the *St George,* its form did not change. Throughout the research period the ultimate wad was constructed from yarns of old rope wrapped into a ball and finished by a series of tight horizontal, vertical and diagonal wraps. Before 1779, gunner's inventories list wadding in its junk form but after it states 1/3 must be supplied in ready-made wads. The evidence from the *Invincible* demonstrates that vessels were issued with several hundred pre-made wads before the documented stipulation in 1779. It is likely that ships were always issued with pre-made wads but the amount may have fluctuated, possibly leaving some ships short of adequate amounts. The documenting of a specific amount in 1779 is yet another example of the navy continuing to enforce proper standards to improve the efficiency and performance of the gunnery system.

The ordnance inventories, alongside the archaeological evidence from *Invincible,* has identified that vessels were issued with several ton of junk, which came in all manner of sizes and, in the case of the *Invincible,* was stored in the forepeak below the main gunner's store. The wads recovered from the barrel of the *Stirling Castle's* demi-cannon, and a handful of wads from the *Invincible's* assemblage, have demonstrated that those made aboard were not always of the same standard as those made ashore. Whether due to haste or lack of skill, some wads were only constructed from the strands rather than individual yarns. With the case of the *Stirling Castle* the loader of the demi-cannon tied two wads together, possibly to make up for their poor construction.

Ladle
The form of the ladle does not change from the *Mary Rose* through to the *St George*. It was essentially a rammer head fitted with a copper scoop at the end of wooden stave. The scoop was long enough to hold a powder charge. Although the design of the ladle did not change throughout the study period, its function did. Initially it was used to load the powder charge when it was in loose form, but the adoption of cartridges negated the need for the scoop as the cartridge could be handled and simply pushed down by the rammer. Despite being made redundant in the loading process it remains part of the gunner's implements and appears in all inventories in small numbers. It was still an essential piece of equipment because there were

times when the gun required unloading and the semi-circular scoop was ideal for retrieving the wads, shot and powder charge from the barrel.

9.3.4 *Firing*

This section will discuss the developments in the equipment used in firing the guns. It includes the priming wire used to expose the powder in the powder bag to the priming powder in the vent, the linstock and slow match, and then progresses to the innovation of the cannon lock, which were the tools used to ignite the priming powder. There were, of course, other pieces of equipment that can be categorised under firing equipment, including the powder horn and priming tubes that contained the priming powder. Little evidence of these have survived and they were not found in the case studies. They will therefore not be a focus, but will be mentioned in relation to the main pieces of equipment.

Linstock

The linstock was a lightweight wooden stick that gripped a slow match, and which was held at arm's length by the gun captain when firing the gun. They are particularly rare in the archaeological record as, due to their very nature, they would have easily floated away during the wrecking process or been eroded rapidly by the physical and biological environment. It was therefore quite incredible that 29 of the 30 linstocks issued to the *London* in 1665 were found during the excavation of the site. The *London* assemblage is currently providing the physical evidence of the next generation of linstocks after the *Mary Rose,* at least from the English Navy; linstocks were found on the Spanish Armada wrecks of 1588 and displayed ornate carvings similar to those from the *Mary Rose* (Martin and Parker 1988, p. 200). When comparing the linstocks from the *London* with those from the *Mary Rose* the most obvious difference is the loss of the personalised decoration. The *London* examples, although not identical, were of a similar style that had been turned on a lathe. This was because the linstock was no longer the personal property of the Master Gunner but instead were the property of the Board of Ordnance, their listing in 17th century ordnance inventories are evidence of that.

The production of the linstock demonstrates that the roll and status of the Master Gunner had changed. No longer was the Master Gunner in charge of firing the gun but instead his responsibility—no less important—was in the organisation and maintenance of the gunnery system. The responsibility of firing the guns was left to gun captains under the general command of an Officer and, during action, the Master Gunner would have been found preparing cartridges in the magazine.

According to the ordnance inventories, at some point during the first quarter of the 18th century linstocks are no longer listed in the inventories of the larger warships, only the slow-match. This would suggest the linstock was made redundant. The *Invincible,* which was trialling the new cannon locks for the 9-pounder guns, was also using the more traditional ignition by slow-match for the larger guns. Evidence of the slow-match was found in a fearnought cloth pouch described in section 7.3.4 of chapter seven. If the pouch was used to fire the guns, its compact nature would have meant the person firing the gun was much closer to it and therefore in a more perilous position from both the ignition and the recoil. Its advantage, however, if used in this way, was that it made igniting the gun more efficient, especially when the ship was rolling and pitching. This was potentially a transition to finding a more efficient way of firing the guns and one that would have increased the rate of fire prior to the introduction of the cannon lock. Despite increased efficiency, however, it could be argued that the slow-match pouch provides a rather haphazard and dangerous method. An alternative hypothesis for the lack of linstocks could simply be that their relative ease of construction led the gun captains to make their own.

Remaining with the period of the *Invincible,* significant improvements in naval gunnery were instigated under the Anson administration, specifically in the serving and firing of the guns. The evidence of this survives both on the site of *Invincible* and in historical records relating directly to *Invincible.* These changes were aimed at increasing the rate and reliability of firing the guns (Robertson 1968, p. 151, Padfield 1973, p. 111, Caruana 1997). The traditional method of firing the gun was to fill the vent or the touch hole with priming powder, poured from a priming horn. A slow-match, either attached to the end of a linstock or within a pouch, would then be used to ignite the priming powder in the vent, which would ignite the charge in the breech of the gun. There were two main issues with this method: first, powder could easily be spilt from the powder horn when filling the vent hole, posing a danger if accidently ignited. Second, igniting the priming powder with the use of a slow-match was never instantaneous when on a moving ship and, if the slow-match was dropped, it could potentially ignite spilt powder.

The solution to these issues was the cannon lock used alongside a priming tube. The gun lock was a mechanism already used to fire hand weapons such as flint lock muskets and pistols. This mechanism was essentially converted to enable attachment to the vent hole at the top of the breech of the gun. It was triggered by pulling a lanyard from a safe distance. The priming tube, initially made of tin, was pre-filled with a measure of priming powder. The tube was inserted down the vent hole and in doing so pricked and exposed the powder charge in the breech. The top of the priming tube had a cup-shaped enlargement which captured the spark from the lock (Caruana 1997, p. 389). The use of the cannon lock and priming tube led to a quicker, safer and more reliable firing method.

The historical record shows that on the 21st October 1755 an order from the commissioners of the Admiralty was given to thirteen ships, including the *Invincible,* to trial the method of cannon locks and priming tins to fire the guns. It continued to state that:

''They will answer much better at sea than the present method of firing only with a match and ought to be introduced on board; but that it should nevertheless be introduced by degrees, that it may be seen whether any difficulties will amend the practice before it is established'' (TNA ADM 2/219).

The only remaining archaeological evidence for these trial locks are the larger sized gun flints, which would have been secured to the cocking handle, the guns and their locks having been salvaged shortly after the ship went aground. The order dated from 21st October 1755 also reveals another improvement made by the Anson administration: the replacement of the paper cartridges with flannel cartridges. The order highlights the inconvenience of rapid firing with the use of paper cartridges (TNA ADM2/219). The rear end of the cartridge tended to remain behind after firing and several of these would clog up the back of the breech and the bottom of the vent hole. This resulted in misfires as the powder cartridges were not able to be ignited (Robertson 1968, p. 151, Caruana 1997, p. 349). The new flannel cartridges eliminated this problem by being totally consumed by the firing (Caruana 1997, p. 349).

As with the introduction of the British built 74-gun ship there was some resistance to these new methods of serving and firing the guns and they didn't become standard until 1790 (Caruana 1997, p. 389). Between 1758 and 1790 improvements were made to the process and firing mechanism and by 1790 cannon locks were fitted to all guns, including the later carronades. Examples were found on the *St George* and the *Pomone,* which were both lost in 1811. These were used in tandem with firing tubes, the design of which of had improved leading to the cannon locks being the standard method for firing the guns. The cannon locks increased the reliability and improved the rate of fire. At longer range it also improved the chances of hitting the target as the lag between igniting the charge and the shot leaving the gun had been greatly reduced.

9.3.5 *Dressing the gun*

This section will discuss the equipment and methods for dressing the guns when not in use. The main case studies have demonstrated that the ways the guns were maintained when not in use did not change throughout the study period. This was because the basic form of the SBML gun did not change. When not in use the guns had to be loaded and ready for action at any moment. To ensure the load remained dry and useable both entry points to the breech of the gun had to be plugged to ensure no moisture could ingress and foul the powder charge. Essentially this consisted of the wooden tampion at the muzzle end and a combination of a wooden plug and lead apron to plug and cover the vent hole at the top of the breech. All of this remained the same with the exception of the lead apron, which only altered in shape to include the addition of the cannon lock. The evidence from the *St George* demonstrated that a wax sealant was used for extra security alongside the tampion against the ingress of water.

9.4 CULTURAL DEVELOPMENTS

9.4.1 *The London*

In the case of the *London* the improvements in warship design and the tactics used to make best use of the guns are clearly evident. This was the coming-of-age of the ship of the line and the general adoption of the line of battle formation, which involved all ships in the fleet unleashing consecutive broadsides into the enemy (Rodger 1996, p. 317). We therefore see the gun being used as the primary weapon to disable and defeat the opposing ships, rather than coming alongside to board and fight hand-to-hand with the opposing crew. The change in tactics spurred a change in ship design by reducing the height of the quarter and forecastle decks and focusing on improving broadside capability. To ensure success with this tactic, improvements had to occur in the way the guns were operated by their crews. To be able to sustain multiple fire without disengaging, the loading of the guns had to become more efficient. The luxury of time and cover afforded by disengaging was no longer available, loading had to be performed under fire from the enemy. Therefore, loading completely inboard was paramount and to achieve this would have taken a higher level of discipline and skill along with the general adoption of the rope sponge.

Despite these developments there was still an inherent problem with the navy that meant the rate of progress was perhaps not as rapid as it could have been. The problem was engrained in the ideology of the navy from the top down. The ship was regarded as a status symbol and it was used as the principal method for symbolising the power and prestige of the state (Davies 2008, p. 45, Adams 2013, p. 97), the mid to late 17th century was probably the peak of this. As such, warships were adorned in elaborate painted and gilded carvings. This can be seen in the contemporary illustrations of the *London* (Figures 3.1 and 5.25 and 26) and the numerous other warships drawn by the Van de Veldes' during the Restoration periods (Fox 1980).

Looking at this from a modern perspective the elaborate adornments would have been an indulgence that would have had a negative effect on the overall capability of the naval gunnery system. The extent of the carvings added considerable dead weight, which interfered with the ship's handling and led to overloading (Carr Laughton 2001, p. 14). This would not have helped the larger ships, such as the *London,* where the lower tier was already too close to the waterline and potentially out of commission during moderate seas (Fox 1980, p. 20, Davies 2008, p. 39). However, from a 17th century perspective this grandeur was, as Adams points out '*as much a part of functionality of the ship as the row of guns protruding from the hull'* (Adams 2013, p. 97). In other words, it portrays power and might of King and country, giving confidence to those commanding and serving on board and the ordinary people of the nation looking on. Carr Laughton and more recently Shaun Wallace, following her study of carvings from Scandinavian warships, suggest that a great rivalry between shipwrights contributed to greater and more elaborate adornments (Carr Laughton 2001, p. 23, Wallace 2013, p. 115). This way of thinking does gradually change during the next century with the steady reduction in the amount of carvings (Carr Laughton 2001, pp. 24–29), but the discovery and subsequent conservation of a large stern port quarter carving, of a neo-classical figure, from the wreck of the *Colossus* (1798), shows the symbolic role of the ship was never abandoned (Figure 9.8).

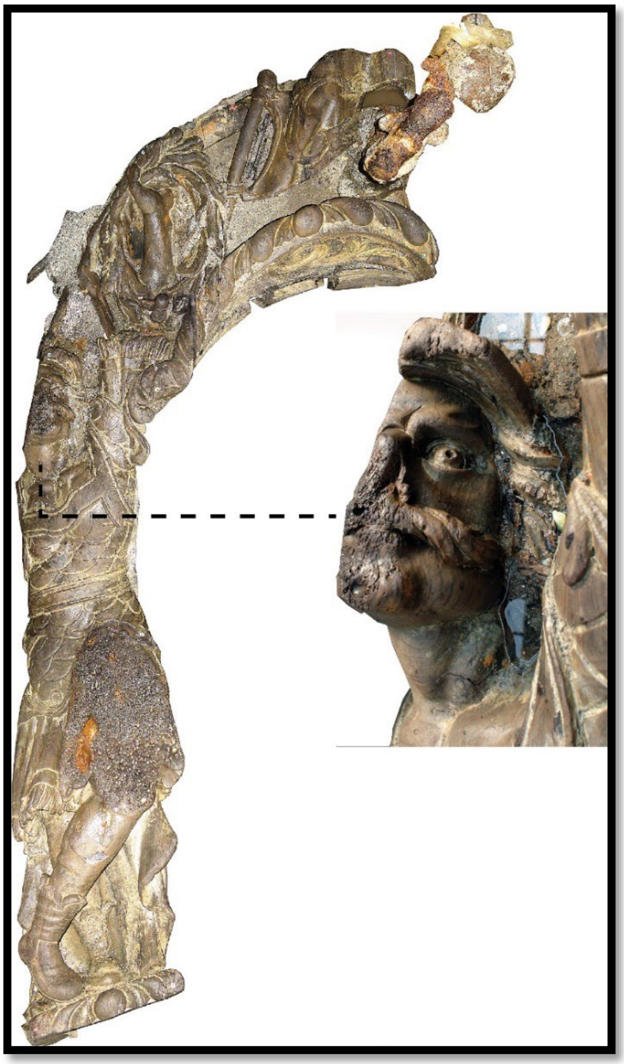

Figure 9.8: Photo of the stern carving recovered from the wreck of *Colossus* and which is on display at the museum on the island of Tresco, Isles of Scilly. It is over 3.3m tall (Cornwall and Isles of Scilly Maritime Archaeology Society 2006, p. 11) (Photos courtesy K. Camidge).

With the case of the *London* the choice of armament and number of guns was also a cause for concern. First, there was the increase in the number of guns carried on board the larger warships of fourth rates and above in 1664, which was in part a reaction to the Dutch building new and bigger ships (Lavery 1987, pp. 114–115, Rodger 2005, p. 217). This led to the *London's* armament increasing from 64 to 76. The increase of guns probably contributed significantly to many of the navy's largest ships having a lower tier perilously close to the waterline; rendered useless in anything other than calm conditions (Fox 1980, p. 20, Davies 2008, p. 40). However, the prestige that went with the greater number of guns appears to have outweigh the disadvantages and it was generally perceived as acceptable by shipwrights, naval administrators and even captains (Davies 2008, p. 40). From a modern perspective this appears incomprehensible and highlights fault through all levels of the navy.

The second issue regarding the ship's armament was that rather than issue the *London* with the optimum guns that were available, precedence was given to bronze, even if that meant issuing lesser calibre weapons. The consequence of this was that the *London* was issued with a mixture of bronze ordnance, consisting of guns of non-standard calibres, different origins and ages. This led to equipment being adapted to fit rather than being designed and made specifically. This would have potentially created problems in the management of the gunnery system. For example, if equipment broke during action, there may not have been an exact alternative that could be swapped out immediately for the defective one. The main gundeck had less broadside capability and was also made up of three different calibres. This could have potentially led to mistakes in supplying the guns with the correct ammunition and charges during the heat of battle. The *London's* guns certainly would have looked impressive and, in ideal conditions, may have performed adequately but, operated under pressure, in rough conditions, and if equipment broke or the supply chain faltered, then the operation of the guns may have been severely hampered. The *London's* guns clearly demonstrate that prestige outweighed the need for performance.

The gun equipment recovered from the *London* demonstrates a high level of versatility and adaptability in the skills of the craftsman, but it equally shows a lack of uniformity in the materials used and in the methods of manufacture. On the one hand this shows skilful craftmanship but, on the other, it takes more time to alter and adapt equipment. Thus, there was a lack of efficiency in the production, the repercussion of which was problems with the supply.

Both the expenditure of shot recorded in the Chatham ledger and the lack of wear on the rammers demonstrate that there was a lack of practice in the operation of the guns. This would not have been unique to *London,* as it was an issue brought on through the general instructions of the time, which limited the amount of times the guns could be fired during practice. The problem was with the Navy Board who, rather than see it as an opportunity to improve the skills of the crew, saw it as an opportunity to save powder and therefore cost. Not only would this have affected the performance of the gun crews, the whole supply chain to the guns would have been impacted and, therefore, the performance of the ship as a whole. Without regular practice there would have been fewer opportunities to identify problems or areas of improvement in both the supply and operation of the gunnery system.

One area of fault that can be attributed directly to those aboard the *London* was the management of the gunnery system during the twelve days leading up to the loss of the ship. The ship may have been weeks away from having to engage the Dutch but maintaining the ship's organisation would have encouraged the maintenance of discipline and professionalism among the crew. This could be blamed on the absence of officers on board, yet the Warrant Officers who were supposedly loyal to Lawson should have had the experience to have the ship ready for sea. For reasons that we may never know, Richard Hodges, the Master Gunner, struggled to evenly distribute the gun's equipment, he also failed to stow hand weapons and their accessories and, finally, the catastrophic loss of the ship could only have been caused by an accident in the main magazine. All these issues were the responsibility of the Master Gunner and demonstrate a lack of organisation and discipline on board that has to be attributed to a lack of professionalism by the Warrant Officers who had command of the ship.

To support this argument of a lack of professionalism and discipline on board the *London,* one must only look at the works of historians studying the diaries of Samuel Pepys, which suggests this was a problem not unique to the *London*. At the start of the Restoration and up to the point the *London* was lost, Pepys had an administrational role as the Clerk of the Act to the Navy Board. During the early years of the Restoration all branches of the naval administration were affected by a lack of funds as the navy was in considerable debt (Tanner 1904, p. 5). This problem filtered all the way down to the dockyards and even the ships, as there was no money to pay dockyard workers or sailors. Inevitably, this created discontent and led to ill-discipline and poor workmanship, the evidence of which is reported first-hand in Pepys' personal diaries. The historian Philip MacDougall provides some of Pepys's diary extracts in his works '*The Chatham Dockyard Story'.* One example describes how Pepys made an impromptu night visit to inspect several ships lying up in the Chatham anchorage in July 1663. Each ship should have had crew and officers on watch and guns ready in case of an attack on the anchorage. Instead, aboard the *Sovereign,* he found no officers and the guns were not prepared for use, with no priming powder available and the guns loaded without shot. On board the *London* there were also no officers, nor anyone awake; he found this to be the case on most ships he visited that night (MacDougall 1987, p. 38). Peter Pett, the Commissioner of Chatham, reported in November 1665 that the dockyard workers were close to mutiny and there was no way of disciplining them (MacDougall 1987, p. 39). These accounts help build a better understanding of the atmosphere at Chatham Dockyard at the time when the *London* was being prepared for her new command, and the reasons why

Richard Hodges and other Warrant Officers struggled to have the stores and equipment properly stowed before the ship left Chatham.

As well as a lack of pay Pepys realised much of the problem stemmed from poor management and, with the case of Chatham, blamed Commissioner Peter Pett. The problem was also with the officers of the Navy Board including the Surveyor who Pepys accused of neglecting to present reports on the dockyard ships and stores (Tanner 1904, p. 30).

Due to the catastrophic nature of the *London's* loss and the lack of survivors to account for what happened at the time and in the days leading up to the loss—common to many shipwrecks—we have to follow a theoretical pathway to determine the actions and behaviours of those on board. This has been led through the detailed analysis of archaeological data (e.g. Adams 2013, Hocker 2013, Rönnby 2013a), by analysing the details on the objects, their spatial distribution on the ship and relationship with other objects, in conjunction with a thorough examination of historical sources. This delivered a reliable insight and a better understanding of naval gunnery from this period of the 17^{th} century. The details recorded on the *London's* gun equipment identified a reactive and problem-solving culture, reacting to broader issues in the naval administration, with a lack of standardisation. The spatial distribution revealed a lack of organisation and discipline and alongside thorough historical research it became clear that this was not unique to the *London* but widespread.

Although there were obvious improvements in the equipment, tactics and the general ability of the navy, the archaeology discussed in this research has really revealed the problem areas that were rooted in all levels of the navy and why Samuel Pepys—when he became Secretary of the Admiralty—lobbied for several reforming measures. These included standardisation of the design of ships, guns and rigging, as well as examination for Officers (Knighton 2003, p. 113), all of which contributed to the increased professionalism of the Royal Navy.

9.4.2 *The Hazardous*

One can see from the archaeology analysed in chapter six that there has been little change since the time of the *London* in the design, style, and form in the equipment used to operate and maintain the guns. The greatest developments occurred in the culture of the naval administration with the recognition that there was a general need for improvement, brought on by the experiences of the three Anglo-Dutch wars. From a historical perspective it has been well documented that this was a key period in the development of the Royal Navy, with Samuel Pepys as Secretary of the Admiralty and the main orchestrator in introducing a series of reforming measures to create a more professional navy (Knighton 2003). These measures included setting out clear establishments in the arming of the fleet with the intention of making the gunnery system simpler to manage and operate. The historical and archaeological record show that this was not a straightforward transition and that there was neither the infrastructure nor the supplies to meet the early Establishments. The evidence from the *Hazardous* shows that this continued after the 1703 Establishment.

In spite of there being several attempts between 1677 and 1703 to create uniformity in the arming of the Royal Navy ships, by 1706 the supply still could not keep up with demand. This would have been further exacerbated by the capture of foreign vessels, such as the *Hazardous*. The wreck of *Hazardous* is providing critical evidence on how ship's crews and the Navy Board in general dealt with this problem and the effects it may have had on the gunnery system.

The evidence from the *Hazardous* shows that one way the Navy Board dealt with the shortage of appropriate guns in the Board of Ordnance gun stocks was to keep and reuse the captured guns. This was nothing new, the *London* is a prime example. The problem that the Navy Board had during this period was that there was now a stricter Establishment to adhere to for arming each rate of ship, and foreign guns often had slightly different calibres or were of non-standard calibres. The *Hazardous* is evidence that during times of war, when the necessity was greater, captured foreign guns were kept and re-issued to the prize ship, along with the ammunition. Fortunately, with the case of the *Hazardous'* guns, they were of similar calibres to that of the English, which made it straight forward to keep the guns and use both French and English shot.

The archaeology shows the French carriages were also kept with only relatively minor alterations to convert them to the English method of breeching. The discovery of spare loading equipment demonstrates that English gun accessories could also be used with the French guns. This is a good example of making best use of captured equipment in a way that did not impact on how the guns were operated and maintained. It shows how the navy could adapt, making the English gunnery system work in essentially a French ship with French guns and equipment (the carriages). There was therefore still the need to improvise and adapt, but to a lesser extent compared to the *London,* and there appears to have been more thought to ensure the gunnery system was not compromised.

The reusing of guns from larger French vessels, which carried a main gundeck armament of 36-pounders, would have been more problematic because the difference in size between it and the English 32-pounder was too great. These types were probably melted down and used to cast new guns, and guns or smaller bores were bored up (Personal communication Ruth Brown, ordnance specialist). Although the *Hazardous'* armament did not match the current 1703 Establishment for a fourth-rate (TNA WO55/1803), it did at least have uniformity in gun calibres on each deck. For the Master Gunner and his crew this was particularly important as it greatly simplified the supply and maintenance of the gunnery system.

The *Hazardous* and Great Storm Wrecks are providing a much better understanding of the different types of shot and how it was stored and distributed around the ship. The evidence from the *Hazardous* in particular shows that there were several types of shot, all of which served a different purpose, and their location on the gundecks demonstrates that the ship was prepared to use all types immediately. However, what is still poorly understood is how the shot would have been secured on the decks so as not to be a danger to crew or equipment. In the conditions that the *Hazardous* was lost in one would expect that the shot must have been secured in a way that stopped it coming out of its holders. The evidence from the *Stirling Castle* demonstrates that the guns were given double security during rough conditions and I suspect equal attention would have been given to the shot to avoid serious injuries from this becoming loose.

The analysis of the shot from *Hazardous* has revealed much more than merely size and type. The details found on the round shot, such as the casting lines, sprues and plugs have identified the methods and quality of manufacture, as well as the techniques used to repair defects in the casting. The raised casting lines, large sprues and lead plugs are signs of poorly fitting moulds and speedy casting. Some of the details visible from the double headed hammered shot, such as the differences with the diameters of the two heads of the same shot, also suggests a hasty production. These are the idiosyncratic features that Hocker emphasises can open a path to broader issues (Hocker 2013, p. 82). In this case the increasing size of the navy and pressures to supply the ships with ammunition during a period of war appears to have put considerable pressure on the supplies of shot. From the evidence of the *Hazardous* these pressures appear in some cases to have led to a drop in quality.

Variations in quality are also seen in the manufacture of wadding. Albeit, a very minor detail and an argument predominantly derived from the construction of the wadding extracted from the barrel of the *Stirling Castle's* demi-cannon, this suggests a potential difference in quality between those made on board during a campaign and those originally supplied to the ship. To make a wad from scratch involved deconstructing old rope, known as Junk. The evidence from the later wreck of the *Invincible* has demonstrated that it was supplied with a mixture of readymade wadding as well as junk. The majority of wads were intricately made from individual yarns and a handful were more roughly made from either unpicked strands or sennit, the latter two probably returned from other ships. The junk consisted of cable-laid rope ranging in size from 7 - 26 inch circumference. It would have taken considerable time to separate the hawsers from the cable, followed by separating the strands from the hawser and, finally, by picking the individual yarns from the strands. This task would have been far easier to do ashore where there was space and fewer time constraints.

In the case of the *Stirling Castle* wads, the final phase, and perhaps the most time consuming, was omitted. From an understanding of the *Stirling Castle's* last operation in the Mediterranean, before it was wrecked on the Goodwin Sands, there could be several explanations for the quality of these wads. First, it could have been a deliberate time saving measure brought on by the urgency of battle conditions or, second, the crew were in a poor state of health or simply did not have the skill. Whatever the reason, the quality of the wadding was poor.

The poor quality was recognised, which is why two wads were used in front of the charge, to ensure the power of the charge was not compromised. If there was sub-standard wadding throughout, and if this was not always recognised, and only a single wad in front of the charge was used, then this potentially would have reduced the velocity of the shot and its capability as well as potentially allowing shot and charge to shift in the barrel of the gun when the ship moved. So, poor wadding effects the gunnery system in two ways: first, poor quality leads to a greater consumption of wadding and therefore the ship goes through its supply at a faster rate, and, second, if unrecognised it reduces the velocity of the shot and therefore its destructive capability.

The fact that there is evidence of poor quality wadding from two sites spanning 52 years suggests this was probably not uncommon and was the reason why by 1779 it was stipulated that one third of the junk had to be supplied as wads. This has provided an insight into shipboard culture and how high-pressure situations, the maritime environment and the general condition on board, affected the everyday life and duties of the crew. It also suggests there was a potential issue with the supply of ready-made wads prior to 1779 and that the specific stipulation of the amount of wads ensured ships had adequate amounts before leaving harbour.

9.4.3 *The Invincible*

The *Invincible* has provided archaeological evidence identifying cultural and behavioural changes in the Royal Navy, much of which has not been seen elsewhere, and which had a clear impact on the naval gunnery system. Evidence from the ship, including several of the aforementioned technological developments in the construction of the ship, can be used to infer cultural changes.

First, the internal areas of the ship concerning gunnery show evidence of change. These areas were on the forward sections of the orlop and hold where spare equipment and gun powder were stored. The surviving section of the orlop, in Trench 1, reveals that the inside of the hull had inverted cladding. This was installed to reduce dampness and stop stores from potentially rotting. During the 1990s, a trench was excavated extending across the remains of the bow of the *Hazardous*. The excavation revealed no evidence of internal cladding. The evidence from *Invincible*, as far as the author is aware, is the earliest known evidence of this internal cladding that has been recorded on a wreck of the Royal Navy. Evidence from the later wreck of the *Colossus* shows this was still being practised in 1798 (Camidge 2002, p. 35).

The *Invincible* is also providing the first archaeological evidence for plastering between layers of planking surrounding the magazine and filling rooms. According to the building contract of 70-gun ships in 1755, the plastering was added as a safety measure (TNA ADM106/3072). The contract doesn't say what the plaster does exactly as a safety measure, but it would have had at least three positive effects. First, the plaster would seal any gaps between the seams of the planking, which would stop drafts of air that had the potential to transport powder dust from the magazine to adjacent areas of the ship; the powder dust could potentially ignite if exposed to naked candlelights in other compartments of the ship. The second benefit was that the plaster was fire retardant and therefore would have offered some protection if a fire broke out in the rooms around the magazine, allowing time to put out the fire before it reached the magazine. The third benefit of the plaster is its moisture absorbing properties, which would have helped keep the magazine and filling room dry.

Both these developments—the inverted cladding and the addition of plaster between layers of planking—are surely technological developments, but their addition also demonstrates a clear cultural change. It shows the move from a reactive culture, as seen in earlier ships such as the *London* and the *Hazardous* to a pro-active, preventative one.

Remaining with the management of gunpowder, the wreck of *Invincible* has produced the most complete archaeological evidence for the storage and transfer of gunpowder from barrel to cartridge case. The gunpowder was initially stored in barrels that were stacked in the magazine on wooden battens and rails. This kept the barrels away from the dampness of the sides and floor of the hold. The barrels were bound in copper and hazel hoops, so there was no possibility of causing a spark during movement. Immediately forward of the magazine was the filling room, which was made of a system of shelves with shifting battens and drawers for storing powder charges. The evidence from *Invincible* included wooden boxes with copper powder measures used for transferring powder into the cartridges, which were then placed into wooden cartridge cases to be transported to the gundecks. This shows that there was a very meticulous method for the transfer of gun powder to ensure safety. The evidence from *Invincible* is showing there was a concerted effort to improve the safety of the ship when managing the gunpowder from the internal construction of the magazine and surrounding areas through to the handling of the gun powder.

Turning the attention to the spare gunnery equipment it is possible to identify a high level of organisation and forward thinking. Heavy and bulky items, which may not have been required so regularly, were stored low down in the forward-most section of the hold. These included gun carriage axles, trucks, wadding and junk. There was further order in the way these objects were stored in this tight and awkward space: the Master Gunner who was in charge of all gunnery stores had utilised not only the space but the features of the structure of the hold. The large breast hooks that extended horizontally across the bow were used like a shelf to stack the spare axles. The junk was then packed to smother and jam the axles in, so they wouldn't fall off the breast hook. String bags of gun wads, each with a label denoting the calibre of gun they were intended for, were piled in the centre of the junk. These were stored so they could be easily grabbed when needed but also pieces of junk could be pulled out. Junk was essential for making new wads but also used to make caulking to fill the seams between timber planks. The distribution of the different objects identifies a quite deliberate method of stowing these objects in preparation for a rough voyage, but also in a way that all types of equipment could be accessed if needed. It is these details that provide a window into the behaviour and activities of the crew to get the ship ready for the long voyage. It demonstrates that they were organised but were also thinking ahead and prepared for all types of eventualities by keeping all stores accessible.

Above this storage area was the main gunner's store. Only a small section of it survived but as the wreck of the *Invincible* is healed over onto her port side much of the gunner's stores were found bunched up on the remains of the port side. The smaller and lighter objects were found here, consisting of the implements used in the operation of the guns. There would have been a lot of wear, tear and strain on these less robust pieces and they were more likely to be replaced. For that reason, it was practical to store this type of spare equipment on the orlop, where it was more readily available. Like the wadding and carriage axles, most of the spare gun equipment was marked with the calibre of gun it was intended for. The evidence of marking and labelling is the most obvious development between *Invincible* and the earlier wrecks. The habit of marking-up the equipment was most likely a product of standardisation, which by the period of *Invincible* was engrained into the culture of the navy and the manufacturers of the equipment. As the type of guns for each rate of ship was standardised, equipment could be produced en masse, specific to those guns. Therefore, there was no longer the need to adapt or alter equipment, which was evident on both the *London* and the *Hazardous*. This is why all the spare gun equipment found on the *Invincible* was in perfect condition. Standardisation made both production and use on board much easier and efficient; on board *Invincible* defective equipment could be swapped out like-for-like.

The evidence from the way the gunnery equipment was stored on board *Invincible,* along with the widespread labelling, shows a high level of organisation. To maintain this level of organisation takes professionalism and discipline. During a time when there was little development in the technology of the gun and most major powers had similar vessels, the one aspect that may give you the edge over your enemy would be having a more organised, professional and disciplined crew. The *Invincible* has certainly provided the archaeological evidence that suggests this was the case on board. These qualities gave the Royal Navy the edge over the other major naval powers of the time.

9.4.4 *The Colossus and St George*

Although the evidence from the sites representing the later Revolutionary and Napoleonic wars has been less abundant with regards to organisation and distribution of equipment and stores, there has been nothing to suggest the culture of the Royal Navy was any different in that respect. Using the details from ship's plans alongside the archaeology, it is evident that the location of spare equipment, shot and powder on board large warships did not really change from the time of *Invincible* up to the *St George*, with the exception of the addition of a middle powder room appearing on the larger warships (Lavery 1987, p. 145). It is, therefore, safe to assume the navy was still extremely organised and professional with regard to the maintenance of the gunnery system. By the end of the century mass production of equipment was greatly boosted by steam powered machinery at the saw and block mills. These were the world's first assembly line of machine tools marking the beginning of the industrial age (Rodger 2005, p. 476). They essentially improved and made the supply of gunnery equipment much more efficient.

What is clear from the archaeological evidence, from a cultural perspective, is that there was now a ruthlessness to the practice of gunnery. The shipboard culture was not only formed on the basis of high levels of organisation and professionalism but there was also a steely determination to keep the guns operational to their maximum potential, no matter the circumstances. This coincides with the adoption of an extremely aggressive fighting tactic of heading straight for the enemy line and breaking it, as performed by Nelson at Trafalgar. The general adoption of this tactic was an ideal time for the introduction of the carronade, a new short, lightweight but high calibre weapon that had devastating power at short range (Wilson 2014, p. 376). The evidence from the *St George* has shown larger warships carried 32-pounder carronades on the quarter and forecastle decks. These would have replaced some of the 12-pounder long guns, therefore increasing the ship's overall weight of shot and while tactics remained at short range these types of guns could be used to devastating effect.

The gunnery equipment recorded from the *St George*, specifically the gun carriages, have been refined to reduce the chances of malfunction or enable the guns to function even when damaged. In addition, all the guns were fitted with cannon locks to ensure a reliable and rapid rate of fire, and the evidence of double shotting and the adoption of the carronade shows the intention is to get as close as possible to the enemy and cause maximum damage.

These tactics and procedures are well known from historical accounts of great fleet battles, such as at Trafalgar (Adkins 2005), but less well-known, and what the *St George* has demonstrated, is that the navy were prepared to do this during more general operations. In the waters of the Baltic where the *St George* was serving as an escort to a merchant fleet, the danger came from the Danish navy, which consisted of much smaller vessels such as brigs and gunboats (Rodger 2005, p. 558). These were not great ships of the line but instead they were fast and manoeuvrable, praying on the slower and more vulnerable merchant ships transporting vital Baltic goods and materials. They proved their threat in 1810 when they were used to great effect when they captured an entire convoy of 47 merchant ships off the island of Skaw (Rodger 2005, p. 558). The deployment of ships like the *St George* in the Baltic showed the navy took the threat from the Danish navy seriously; the way in which the ship's guns were loaded demonstrated they were prepared to use the same force as they would against larger warships. These developments are all centred on the tactic of getting close to the enemy to unleash and maintain a devastating, rapid and continuous barrage of fire.

Although close range was the preferred tactic, there were occasions when aiming the gun at targets at greater distance or at different angles was necessary, which the *Colossus* provides the evidence for with the inclusion of the sweep piece. It demonstrates that the navy had the ability to fight at any range. It also shows a desire to improve the way the guns could be operated to maximise the potential of, essentially, a weapon that had not changed since its first use on board ship.

Returning to the details of construction of equipment, it has been established already in section 9.3.2 that there was a high level of craftsmanship shown in the construction of the gun carriages. The small repair piece (Artefact **6000-UNR**) was finished in the same manner with edges chamfered at 45 degrees and additional fixings behind the trunnion recess seated in counter sunk holes and possibly filled. This demonstrates that the ship's carpenters showed a similar level of skill and care to match the quality of the original. It is these small details that only the archaeology can provide, and which offer an insight into the character of individuals on board.

Other signs of professionalism and good seamanship comes from the load that was excavated from the barrel of the 12-pounder gun. The preservation of the tampion, wads, shot and even the charge was exceptional. This was made possible by the crew that made sure there was a watertight seal at the muzzle and vent hole of the gun to protect the load. The 12-pounder gun was stationed on the upper gundeck, much of which was exposed to the elements, so it was essential the powder charge stayed dry. To make sure this happened the gun crew used wax between the tampion and the side wall of the muzzle and hammered it in tightly, Caruana refers to this as puttied in (Caruana 1997, p. 112). On top of that, they ensured the powder charge and round shots would not roll around in the barrel by adding extra wads, which also acted to soak up any moisture that might enter the barrel.

9.5 Future Work

During the process of bringing this research of English/British naval gunnery under one coherent study, it has illuminated both periods and areas of gunnery where there are gaps in knowledge, and where new discoveries and research are needed. Beginning with the periods, there is a huge hole that extends from the Tudor (post *Mary Rose)* and the early Stuart. This period sees two important transitions in warship design and tactics deployed in the use of the guns. First, the large carracks with their high bow and stern castles are replaced by the much smaller and sleeker 'Elizabethan/race-built galleons'. Therefore, the movement away from the old tactic of coming alongside and the crew boarding to finish the battle to the new tactic of manoeuvring swiftly into position to use the great guns more decisively at range to win the fight. The second transition was from these race-built galleons to the larger ships with the great guns on multiple decks. The latter would become the ships of the line when the general mêlée tactic was replaced by the line ahead as discussed in section 1.1. Here there is a movement back to construct larger vessels with higher bow and stern castles to have the capability of all-round fire with the great guns, which was most evident through the construction of the 100-gun *Sovereign of the Seas* in 1638 (Konstam 2008, p. 293)

The changes in ship design and tactics influences the whole gunnery system from operation through to organisation. It would therefore be interesting to see how things evolved from the time of the *Mary Rose*. For example, have the gundecks been decluttered by this point and stores and cabins moved to the decks below?; is there room for the guns to recoil into the load position, and if so, were the guns secured in a way that allowed it?; how and where were the munitions, powder and spare equipment stored? The problem of course is finding the archaeological sites with the preservation of relevant structures containing significant material relating to gunnery. There are sites from this period such as the *Gresham Ship c.*1590s (Auer and Maarleveld 2014, Milne and Sully 2014), the *Sea Venture* 1609 (Adams 1985), the *Warwick* 1619 (Bojakowski and Custer-Bojakowski 2017) and previously referred to in section 2.5.4 the Alderney Wreck *c.* 1590s (Monaghan and Bound 2001). These sites were armed merchantmen, the latter possibly hired by the Navy as a supply and troop ship (Monaghan and Bound 2001, p. 172). Although these vessels were merchantmen, they were built robustly to carry out ocean voyages and to be able to defend themselves. During these periods armed merchantmen were often hired by the Navy to strengthen the fleet (Rodger 2004, p. 342). Therefore, these sites have a legitimate role in understanding naval gunnery from this period. The Alderney Wreck and the *Warwick* have demonstrated that although relatively lightly armed they carried several types of shot appropriate different targets on a ship. So, material does exist, and it is useful in understanding the typologies, and methods of manufacture but on its own lacks details regarding organisation and operation, which is critical in understanding the skills and abilities of those on board.

Coherent sections of hull structure survive from these sites too but despite this, the guns and shot these sites have lacked the depth of stratigraphy that could support the survival of internal structures and quantities of material culture that could provide the evidence for the organisation, maintenance and operation of the guns. However, when a site is found with the depth of stratigraphy to support the survival of three-dimensional structures and large quantities of material culture relating to gunnery and other aspects of shipboard life then *Gresham Ship, Sea Venture* and the *Warwick,* researched as a collective, with new sites, will potentially play an important role in enhancing the understanding of gunnery from this period.

On a more immediate note and a research topic that could be pursued with known sites and existing data is in the examination of shot. This research, along with Hildred's on the shot from the *Mary Rose* (Hildred 2011) and McElvogue's on the shot from the Alderney Wreck (McElvogue 1999) has shown there are many features visible on the shot that identify typologies, processes and products of manufacture and use. Details such as the casting sprue and line on the iron round shot not only show how the shot was made but also its quality. The examination of the shot from the *Hazardous* in sections 6.4.1 and 6.4.2 and the *Invincible* in section 7.4.1 identify a potential difference in quality and this leads to more questions. For example, was there a greater demand in 1706? Did this put pressure on the manufacturers to keep up with demand? If so, did this lead to a drop in quality or was the technology behind casting shot better by 1758? As well as casting marks, the shot from *Hazardous* and *Invincible* exhibited different maker's marks and it is far from certain whether these were made into the mould or chiselled into the shot after. The makers mark presumably identify different foundries. It would therefore be useful to research where and how the shot was cast. To substantiate these questions samples from other sites are necessary to see if these are anomalies or are there patterns emerging. Iron shot is often overlooked and left on the seabed as it is notoriously difficult to conserve, but hopefully this research has shown the benefits of analysing it in detail and the potential questions it could answer.

9.6 Summary

This discussion has looked at both technological and cultural developments throughout the study period, breaking these down into various components and demonstrating where changes have occurred and, indeed, where they have not. Complimenting this, where technological changes have not occurred, the changes seen are often cultural, in the organisation, maintenance and operation of equipment. We have also seen how these two themes are often intertwined, such as when certain pieces of equipment have been altered and adapted, thus identifying the everyday challenges faced by the crew and the ways in which they overcame them. As we progress through the study period, we can see lessons have been learnt: adaptations are no longer ad hoc but deliberate, planned and documented to increase efficiency, reliability and performance. This goes hand-in-hand with a more professional and organised navy.

Chapter 10 Conclusion

This research has enhanced the understanding of British naval gunnery from the Early Modern Period through to the Industrial Revolution. This was achieved through the completion of Objective 1, by investigating the known shipwrecks of the Royal Navy with the focus on five: the *London*, *Hazardous*, *Invincible*, *Colossus* and the *St George,* which form the main case studies. These sites represented apex fighting ships from significant periods in the development of the Navy. Investigations of these shipwrecks included collecting new archaeological data through the most recent underwater excavations and surveys (Objective 2) as well as re-analysing existing data from previous site investigations and museum collections (Objective 3). These sites, studied as a collective, alongside other secondary sites and the historical record (Objectives 1-4), have enabled the charting of key developments in British naval gunnery through time and brought together the available data under one coherent study.

Developments were broken down into two main categories: technological, through improvements made to existing equipment or structures or new inventions critical in the operation of the guns (Objective 5); and cultural, through identifying improvements in the management of the gunnery system ashore and in the organisation, maintenance and operation on board ship (Objective 7). As previously mentioned in section 9.1 technological details and developments often have a cultural context and therefore the two themes are often interconnected (Adams 2013, Hocker 2013, Rönnby 2013a).

This research focused on the gun's equipment and its distribution on the wrecks (Objectives 5 and 6). Each case study chapter analysed the equipment first from a technological perspective, recording its form and composition and, in consultation with the historical record and existing archaeological data, identified the objects and their function and role within the operation of the guns. The equipment was then studied in relation to where it was found within the wreck and in relation to other objects to gain an understanding of how it was organised and maintained around the ship. Where evidence survived or was recorded the munitions and gunpowder were researched with regard to typology, manufacture, use, as well as spatial context. Understanding how the equipment, munitions and powder were organised and maintained on board, and how this changed over time, reflects changes in behaviour and culture of those on board but also those ashore managing the supply. A good example of this is contrasting the poor organisation and distribution of gunnery equipment on the *London,* where we find multiples of the same equipment next to a single gun, with the highly organised gunnery equipment on the *Invincible,* clearly labelled and neatly stored in specific areas of the ship. This difference in on board culture reflects the broader changes seen in management ashore, where improvements in production, organisation and standardisation of the whole system by the time of *Invincible*, had made a significant impact.

In terms of technological developments, these were in most cases minor, focusing on refining the gunnery system to make it more reliable, efficient and deadly. This can be attributed to the simplicity of the SBML gun and that its basic form did not change throughout the study period. There were of course key technological developments that had a significant impact on the gun's capability at sea, three of which stand out. First, the adoption of the four wheeled carriage, as seen on the *Mary Rose*, whose compact and robust build gave the operation of the gun greater control, stability and manoeuvrability on the gundecks. Its early adoption by the English Navy gave it a significant advantage over foes that were using the larger and more cumbersome two wheeled variety. The evidence from the case studies have shown how the design of the carriage was regularly adapted to ultimately improve the performance and reliability of operating the gun. No better for showing these improvements were the carriages from the *St George*, which also showed, through their remarkable preservation revealing beautifully chamfered edges and counter sunk fixing holes, the skill and care of the carriage makers. The success of the four wheeled carriage can be measured by the fact it remained in service throughout the SBML era, with its lineage traced back to the early examples found on the *Mary Rose.*

As fighting tactics changed in the 17th century and it became necessary for ships to fire repetitive broadsides without disengaging, the ability to load within the relative safety of the hull was critical. This was not possible with the sponge and rammer on the end of a long wooden stave. Instead, the very simple design change from a wooden stave to a stiffened rope made it possible to reload the gun within the relative safety of the hull. The introduction of the rope sponge, which, being low-tech, has often been overlooked, was another key technological development that improved the capabilities of the crew to operate the guns. It became an essential piece of equipment issued to every gun on board from the mid-17th century, as evident from the *London* through to at least the time of the *St George* in 1811.

Fighting at sea, side by side with the enemy was extremely attritional by the 18th century, as enemies shared the same weapons system with equal capabilities and similar types of ships. The winner was generally the one that could land the most shot, disabling the opposing ship and killing the greatest number of their crew. A fast and accurate rate of fire was therefore critical in winning the fight and this desire led to the third key development by the mid-18th century: the cannon lock. Alongside the priming tube the cannon lock made the process of firing the gun more reliable, efficient and safer as the mechanism was triggered by a quick and simple tug of a lanyard that led to the ignition of the powder without delay. It contributed, alongside the skill and discipline of the crew, to a faster and more accurate rate of fire. This new innovative firing method was attributed to the Anson administration of the 1750s, the evidence of which survives from the flints found on the wreck of *Invincible* and the cannon locks found on the *St George* and it continued to the end of the SBML era.

The developments discussed above, in addition to the many others contained within the results chapter, demonstrate that through the objectives set out in Section 1.3, this research has achieved its key aims. However, these developments give us more than the improvements in technology, they provide evidence of the everyday routines, behaviours and activities of the people behind the weapons system through the unique details found on the objects. These details alongside the spatial analysis give the objects a cultural context, identifying the skills and abilities of the crew and craft people ashore (Adams 2013, Hocker 2013, Rönnby 2013a). This indicates that the greatest developments were actually in the culture of the Navy and the five main case studies have shown this progression.

The details found on the archaeology, such as tool marks, alterations and adaptions, reflect particular choices and were made for specific reasons. During the periods of the *London* and the *Hazardous* the archaeology shows a reactive culture in the navy. Those involved in maintaining or operating the gunnery system were often having to improvise and adapt on the job to ensure the guns and equipment functioned as they should. Their problems generally stemmed from broader issues within the administration of the navy with problems such as a lack of standardisation in the arming of the fleet and keeping up with demand. The archaeology demonstrates how there was a domino effect that filtered down to on board ship and which was evident by the alterations made to equipment, such as on the *London's* gun carriage and rammers and the *Hazardous'* gun carriages. The tool marks and alterations to equipment provide an insight into the people directly involved, identify the everyday challenges they encountered and, most importantly, the ad hoc methods and techniques they used to overcome these problems. This is the information that makes the archaeology so important and separates it from previous historical research on the topic. This really emphasises Hocker's point that by understanding the meaning of unique details, whether it be from the ships themselves or from the objects on board, we can create a richer understanding of human behaviour at the same time producing the real data required for the study of more broader trends and theoretical ideas (Hocker 2013, p. 72).

By the time of the *Invincible* and later, the *Colossus* and the *St George,* lessons had been learned and experience led to deliberate changes in the design of equipment and the supply of munitions and other stores. The new features on equipment along with quantities and make-up of stores were being documented to ensure standards and quality were maintained. The evidence from these wrecks (chapters seven and eight) showed that there was progression with change in mind set from reactive to preventative. This was likely to have occurred much earlier, after the time of the *Hazardous* and before the *Invincible,* but as yet there is a lack of archaeological evidence. With *Invincible,* it was most evident through the layout and construction of the internal structures of the ship where gunnery related material was stored. It was clear that the navy had learned lessons from the past and improvements were planned and carefully thought-out. The changes were conscious attempts to improve conditions for storing equipment and other stores to ensure they stayed dry and usable, such as the inverted internal cladding and use of plaster found on the *Invincible* and *Colossus* (sections 7.2.1 and 7.4.3), absent from earlier sites. Safety when storing and handling powder was a major improvement on board *Invincible*, as accidental powder explosions were a common problem; look no further than the *London.* This latter emphasis on good organisation and maintenance was helped by the improvements in the administration of the navy and the benefits of standardisation. Standardisation made the management and operation of the gunnery system both more efficient and effective.

This research has catalogued the equipment, stores and munitions relating to gunnery in the Royal Navy and tracked the changes and developments over the whole study period. However, through the collection, analysis and application of new and existing archaeological evidence this goes far beyond the previous understanding gleaned from the historical record. The significance of this research is that it has revealed the actions of the people directly involved in all facets of the naval gunnery system. The small idiosyncratic details left by the

maker or user, and the methods by which equipment was stored and organised, identify the everyday routines that were so normal they were often left out of the written and iconographic records. It is these details, though, that have been the most revealing about shipboard life and culture. Ships are made up of hundreds of individuals and, although part of a structured society, the reality is that people don't always follow rules, nor do they do things in the same way - they react to immediate issues and challenges around them as well as broader issues within the navy (Hocker 2013, p. 73). Because of this, these idiosyncratic details are often unique, providing a wealth of previously overlooked information. Through the unlocking and interpretation of these details, each case study has provided a detailed account of the reality of naval gunnery and warfare at sea in the age of sail. This has shown what was actually provided and how it was used, often after adaptation, and returns us to Muckelroy's original point highlighted at the start of this thesis:
"*the seabed remains show what actually existed, rather than what was thought to be there or should have been there*" (Muckelroy 1978, p. 215).

Glossary of Terms

Terminology – The parts of a gun referred to in this thesis include the bore (the front or mouth, through which the shot exits upon firing), the breech (the solid back end), the touch-hole or vent (a small hole at the breech on the top of the gun which goes through the wall of the gun and into the cylinder) and the cascable (the metal behind the breech, which generally tapers to end in a button or knob).

Apron of lead – Covers of lead. Lead patch often moulded to fit over the back of the gun to cover the touch hole or vent; generally with holes on sides to accept ties.

Cannon lock – flint lock firing mechanism attached next to the touch hole of the gun and used to ignite the priming powder to fire the gun.

Carronade – First manufactured by the Carron Iron Company at Falkirk, Scotland. It was a short and light gun in relation to the calibre. It was introduced into British service in 1779 and used as a short ranged weapon.

Cases of wood – Also known as cartridge cases or boxes. They held a single charge of powder and were used to transport the charge from the filling room to the guns.

Coin – Also known as Quoin, Coyne. A timber wedge placed under the breech end of the gun to change elevation.

Crowbars – 'Crowes of yron'/crowes. Iron crowbars. Rod of iron with one flattened end which can be used to move objects.

Drake – A gun which was lighter and shorter than those standard to their calibre and which had a tapered bore (Blackmore 1976, p. 228).

Gun – Referring to heavy artillery carried on ships, which there are many types and calibres. Up to the early 18th century English guns were primarily identified by their traditional names and after by their calibres. The last quarter of the 17th century was a transitional phase, when the older guns, with traditional names and new types of guns, identified through their calibres, were both used on board ships. The latter system of gun identification from the largest calibre to the smallest were 42-pounder, 32-pounder, 24- pounder, 18-pounder, 12-pounder, 9-pounder and 6-pounder.

Traditional English cast guns identified by their name, with equivalent calibre in brackets where appropriate, from largest to smallest and are as follows:

Cannon – Also known as cannon of 8 or cannon royal. A gun with a bore of 8 inches and weight of shot of 64lb.

Cannon of 7 (42-pounder) – A gun with a bore of 7 inches and a weight of shot of 39lb.

Demi cannons (32-pounder) – A gun with a bore up to 6 ½ inches and a weight of shot of 32lb.

Culverins (18-pounder) – a gun long in proportion to its bore. Generally has a bore of 5 ½ inches and a weight of shot of 18lb.

Demi culverins (9-pounder) – A gun with a bore up to 4 ¾ inches and a weight of shot of 9lb.

Sakers – A gun with a bore ranging from 3- 4 inches and a weight of shot 4-7lb.

Hail shot piece – A muzzle loading anti-personnel weapon. They can also wrought iron and breech loading.

Minions – A gun with a bore up to 3 ¼ inches and a weight of shot of 4lb.

Wrought iron guns from the largest to smallest and referred to in the text are as follows:

Port Piece – Breech loading gun firing stone shot

Sling (demi and quarter) – Breech loading gun firing a cast iron shot. It is generally long in relation to its calibre.

Fowler – Breeching loading gun firing small cast shot or stones.

Base of iron – A small bore breech loader much like a swivel gun.

Gun carriage – A wheeled support on which the gun is mounted. It consists of several timber and iron components. The timber components include the cheeks (side brackets with recesses to house the trunnions of the gun and steps to allow leverage points to raise the breech end of the gun), the bed (pre-1725 two pieces of board fastened together to form a platform in which the cheeks bolt onto), axletrees (front and rear axles which the bed and cheeks are mounted on and four trucks are placed), trucks (wheels in which carriage moves on). The iron work includes the capsquares (hinged iron plates which pass over the trunnions and holds in place), ring bolts (attached to sides of the carriage to allow the breeching rope to pass through and on the rear of the carriage for attaching the train tackle), eye bolts (found on the sides of the carriage for the attachment of the gun tackle), linchpin (a pin that passes into a hole between the end of the axle and the truck to hold the truck in place) and forelocks (a thin triangular wedge placed into slits at the end of bolts to hold bolts in place).

Gun flint – A worked flint, wedged shape that is used to create a spark to ignite the priming powder in the touch hole of the gun.

Gunpowder - Either loose, but more often contained within a paper or canvas cartridge (cartouche) of appropriate size in diameter for the gun and of the length required to hold the exact weight of powder for the gun. Cartridges were transported to individual guns in wooden, pewter or copper canisters. Gunpowder was stored in barrels.

Hand crow levers – Also known as a hand spike. Wooden lever between 1.5 and 1.8 metres in length, straight or curved. Used to lever the gun and carriage into position. Usually flattened at one end (sometimes shod with iron) and tapering to a round handle at the other. Traditionally of ash or elm.

Home-bored – Refers to the shape of the bore of a gun. In this case the bore is accurately centred in the barrel and a perfect cylinder from end to end. Therefore opposite to the term drake, which was a tapered bore (Blackmore 1976, p. 232).

Ladle – Powder ladle/ charging ladle/powder scoop. Wooden staff with a cylindrical tapering wooden head around which a copper or copper alloy plate is bent to form a half cylinder. Held with nails. The scoop is of the exact length to provide the correct amount of powder for a specific gun. Fitted to the bore of the gun and staff of the length required to reach the breech. Sometimes a staff is fitted with a ladle head on one end and a rammer on the other.

Junk – The term for old rope and used for the construction of wadding.

Linstock – Wooden staff usually between half a metre and a metre in length around which a slow match is twisted. This enables the gunner to stand at least twice his arm's length away from the gun whilst igniting the powder charge. One end is fashioned to form jaws or pierced with a hole to take the match; later a metal fork with a screw was inserted. The opposite end can be fashioned to form a grip. Sometimes a spike or nail is inserted at the end of the grip so it can be stuck in the deck or the ground.

Priming iron – Priming wire/ primer/ vent pricker/pricker. An iron or copper alloy spike or wire used to clear the vent and to pierce the cartridge just before firing. Can be completely straight or have a screw thread at the end. The top of the wire is usually bent over to form a small handle.

Priming horn - Powder horn/ powder flask. Container for the stronger (priming) gunpowder placed in the touch-hole of the gun. Once lit, this ignites the main powder charge and fires the gun. Often made out of a cow horn fitted with a plug at the lower end and a cap at the top end. Both ends carry rings to attach a string or strap so that it can be worn.

Rammer - Ram. Wooden staff with (often tapered) cylindrical head fixed to it. Long enough to reach the breech of the gun, this is used to place the charge (powder, wad, shot, tampion) and push it to the breech. Fitted to the bore of the gun. Sometimes a staff is fitted with a sponge or a ladle head at one end and a rammer head at the other.

Rope sponge – A strong rope stiffened by spun yarn to which a sponge head and rammer head are attached. Enabled inboard loading without the loader having to expose parts of their body outside the port. It meant gunports could also be closed when loading the gun.

Shot- Different sorts, but always sized to the bore of the gun with 1/20th gap between shot diameter and bore.

Shot gauge – Also known as gages for shot. Ringed gauges made of wood or metal to fit each size of round shot.

Sponge – Sponger /spunge. Wooden staff/stave with a cylindrical head around which sheepskin is nailed, with the wool outwards. Used with a bucket of water to clean the bore after each round. Of sufficient length to reach the back of the breech. Sometimes a staff is fitted with a sponge head at one end and a rammer head at the other.

Slow-match – Match. Lengths of cord impregnated with saltpetre or gunpowder by boiling the cord (lint) in a solution and drying them on a pole. When lit these will burn slowly. Wrapped around the linstock, the match is used to ignite the priming powder and in turn the main charge.

Stool-bed – Provides a platform for the coins to rest. Associated with the transom carriage where the timber bed was dispensed with. The stool-bed extending from the rear axle to an iron bolt through the centre of the carriage.

Tampion/s –Sometimes used in place of a wad during loading; later the turned wooden plug inserted into the muzzle of the gun to protect the bore and keep the charge dry. Sized to fit specific gun types, often transported in reels and snapped off when required.

Wad or wadding- A ball made of rope, hay, or wood placed in the bore, usually after the shot and before the tampion. It is not unusual to have several wads, one before and one or even two after the shot. They help to keep the shot in place during loading, help to absorb the pressure build up from the burning powder and absorb moisture.

Worm – Also called a wad-hook or scraper. Wooden staff/stave with an iron screw on one end. Placed down the barrel of the gun, it must be of sufficient length to reach the end of the breech. It is pushed back and forth to catch any remnants from the previous round and to loosen any rust.

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