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UMI
THE DEVELOPMENT AND UTILIZATION OF SHIP TECHNOLOGY IN THE
ROMAN WORLD IN LATE ANTIQUITY: THIRD TO SEVENTH
CENTURY AD

A Dissertation

by

JEFFREY GLENN ROYAL

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of
DOCTOR OF PHILOSOPHY

May 2002

Major Subject: Anthropology
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ABSTRACT

The Development and Utilization of Ship Technology in the Roman World in Late Antiquity.
Third to Seventh Century AD. (May 2002)
Jeffrey Glenn Royal, B.A., University of North Carolina - Chapel Hill;
B.A., University of North Carolina - Charlotte;
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Co-Chairs of Advisory Committee: Dr. Frederick Hocker
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Between the third and seventh centuries AD, ship and boat construction underwent fundamental transformations for both merchant and military activities. The Roman Empire extended over a vast territory and included numerous cultural groups, some of whose territories were overtaken while others immigrated. Beginning in the fifth century, there were major socio-political revolutions in Europe and the Mediterranean as Germanic and Scythian kingdoms were established on former Roman Imperial territory. Although these indigenous cultures were subjected to Roman influences, they also made a cultural impact. A wide variety of technologies were part of the cultural elements exchanged, including those associated with the construction and use of watercraft. It is imperative to reevaluate transportation technology in this period based on a synthesis of archaeological, iconographic, and historical evidence, and place it within the broader cultural and historical contexts. This research attempts to trace the development in the trends of ship technology for the period and better understand how cultural influences between the various polities and cultural groups of Europe and the Mediterranean affected them. Furthermore, this work will elucidate the role of transportation technology in the building and maintenance of the polities carved out of the territories of the Western Roman Empire after its demise. Thus, areas of investigation include trade, redistribution, communications, and naval tactics.
DEDICATION

To my wife Jaynie who was my inspiration and support on this long journey, and my baby daughter Chiana, our most special treasure. To my parents who unwaveringly encouraged me through all the years.
ACKNOWLEDGMENTS

I would like to thank my wife, Jaynie, who has supported me in many ways during my studies, not only with making this work possible, but with her editing work and by being someone with whom to discuss ideas. My parents, Jack and Rachael, have also supported me throughout my university years and have always given me encouragement in my decision to endeavor for my doctorate.

Special acknowledgments go to several professors who not only assisted in making this a better work, but have made me a better scholar. I have learned much from Dr. Ya'acov Kahanov who has continually given me the opportunity to perform and publish fieldwork, and has been more than generous both personally and professionally. He has been a friend and mentor. A special thanks also goes to another friend and mentor, Dr. Frederick Hocker, who initiated me into the study of maritime archaeology at Texas A&M University. He has also provided me with much experience in the field and helped in every way to further my professional career. Two other professors for whom I also have much respect and admiration, Dr. Cemal Pulak and Dr. Frederick van Doornick, Jr., have exhaustively worked in assisting me with the writing of this research. Their suggestions, editing, and support are most appreciated and I have learned much about the discipline during the process. Thanks also go to Glenn Grieco, Dr. John McManamon, Dr. Avner Raban, Dr. Patricia Sibella, and Prof. Richard Steffy for their advice, teaching, and assistance throughout the years.
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CHAPTER I
INTRODUCTION

Since the first underwater excavations in the 1960s by diving archaeologists, the amount of archaeological remains of ocean craft, river craft, and port facilities has increased dramatically. Much of this material is presented separately in numerous excavation reports or in technical works addressing a single aspect of construction or function. Attempts to chart the technological development of ship construction have traditionally been broad, sweeping through centuries or even millennia of archaeological material. These works often begin in Neolithic and ancient Near Eastern periods and extend through the high Middle Ages. Some of the better and groundbreaking works that have contributed a great deal to our understanding of this development include J. R. Steffy's Wooden Ship Building and the Interpretation of Shipwrecks, S. McGrail's Ancient Boats in Northwest Europe, and O. Cumlin-Pedersen's Aspects of Maritime Scandinavia, AD 200-1200. A different approach was taken in this present work by offering a narrowing of the chronological period of investigation, while expanding the historical context in which the development occurred and drawing on a wider variety of evidence.

This study addresses several questions in relation to water transportation technology and the socio-economic trends of Late Antiquity. The period of Late Antiquity has often been characterized as an era of transition in watercraft construction. Although the entire history of watercraft technology arguably consists of a series of lengthy transitions, as is so with most any technology, it appears that fundamental changes took place more rapidly in the Roman world of Late Antiquity than in earlier periods. These changes included a shift in the primary strength-giving timbers of vessels, and in the order of construction, alterations in attachment methods, and changes in hull shape. Underlying factors in these changes were found in the volatile political and economic environment between the first century BCE and the fourth century CE and in the interaction of two construction traditions during that time. The two traditions were that of the Mediterranean and of North Europe/North Sea region. Economic and political consequences of a Mediterranean once completely controlled by the Roman Empire having fractured into a sea controlled by competing shores, spurred many of the fundamental developments in watercraft construction. The direction of these technological developments was shaped by the Roman contact with the shipbuilding traditions along the north borders of the Empire.

Not only is it imperative to reevaluate transportation technology in this period based on a synthesis of archaeological and epigraphic evidence, it must also be evaluated within the broader cultural context that excavations have further elucidated. In the period of history discussed, the third through

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This dissertation follows the style and format of the Journal of Roman Archaeology.

seventh centuries, there were a large number of cultures interacting within the European and Mediterranean world. The growth of the Roman Empire brought the amalgam of Roman and Hellenistic cultures into contact with the Germanic and Celtic cultures of Europe, the Asiatic cultures of the Near East, and various sedentary and nomadic cultures indigenous to North Africa. The many cultures in these areas were brought under Roman influence, but they also offered their own cultural elements in exchange. These included a wide variety of technologies, such as those associated with water transportation. Shipbuilding techniques in the Mediterranean had been interacting for many centuries between the various cultures around its shores, which resulted in relatively similar methods everywhere with slight regional variations of building. Conversely, the Empire’s spread into northern Europe brought the Mediterranean traditions into contact with heretofore isolated and disparate sets of construction techniques for the first time. Archaeological investigations have also demonstrated the high degree of interconnection between these various cultures in both the economic and political spheres. It is through these connections that technology and ideas were communicated between cultures through the diffusion-innovation process.

Diffusion is a communication process involving both material and ideological elements from one culture to that of another, and can act as an influencing agent on the ideas of individuals in that culture. It is a process for cultural change, although not an explanation of that change. Diffusion of technology is not typically a wholesale adoption of alien cultural ideas, nor necessarily the conscious selection of other cultural elements. Rather it is defined by the type and degree of contacts, as well as the specific problems for which an individual requires a solution. Innovation is a process whereby solutions to problems are developed through experimentation with heretofore untried or unknown solutions. It is not necessary that the solution to a particular problem be a new invention, rather it may have resulted from a solution to a different problem. Marvin Harris has argued successfully that the dichotomy between diffusion and innovation is a false one, stating that it is “logically and empirically false because it rests on the unsupportable notion that independent invention and diffusion are fundamentally different processes.”\(^2\) A novel use of a borrowed cultural element, a partial adoption of an element, and separate parallel developments blur the definitions of diffusion and innovation. Also, problems can be communicated and transferred between cultures just as solutions are. Furthermore, for one to formulate adequate explanatory theories, Harris insists that diffusion and innovation must be utilized as a single process.\(^3\)

Forces influencing individuals in societies have both direct and indirect aspects. More directly influencing forces occur from actual contact between individuals from different societies, such as formal or informal political contacts, population interactions, economic ventures, occupation or subjugation, and military engagements. Indirect influencing forces operate through mediators such as observational reports,

\(^3\) Ibid., p. 378.
the spread of folklore and myth, and down-the-line trade. It is through these direct and indirect forces that the diffusion-innovation process operates. Trade is a fundamental mechanism acting as a direct influencing force. It is often characterized by the exchange of material culture that either possesses or reflects a portion of a culture's technology. Political control, another directly influencing process, results in exposure to a wide range of technological elements for both the dominant and submissive cultures.

Influencing forces also have different intensities. Generally, direct influences are more intense than indirect ones in that they communicate a specific cultural element more quickly and closer to their original form. Other inter-societal factors that affect the intensity of communication between cultures include differential economic and military power, perceived superiority or advantage of the cultural element, and differential technological capabilities. Thus heavy trading relations and political control are highly intense influencing forces between cultures. Ultimately, the diffusion-innovation process acts at the level of the individual, playing against an individual's selectivity. Selectivity by an individual depends on their needs, preconceptions, abilities, comprehension, socio-economic status, and freedom to choose. Hence, when presented with an outside technological concept, an individual may utilize part of it, all of it, or alter all or part of it for their needs. Likewise, a technological solution developed or borrowed from within a culture will also be subject to an individual's selectivity.

During the late Empire of the second and third centuries, individuals were living within a political entity that facilitated the movement of peoples and goods over great areas. From Mesopotamia to Britain, a system of roads and sea-lanes created a cohesive political structure. Within this structure, once separated cultures were operating in an environment of greater interaction and communication. This interaction promoted the spread of cultural material and ideas over a wide geographical and cultural landscape. One of these cultural elements was ship technology, crucial to the economy of Late Antiquity, as well as in maintaining communications and military operations within the large area under Roman control. Since ships and boats are designed to travel, shipbuilding technologies are inherently communicated between cultures that are often quite distant to one another. In the mid-third century, major demographic changes were affecting parts of Europe and the western Mediterranean. By the fourth century all of the Empire's present and former territories were affected, with the upheavals continuing into the sixth century. In the waning years of the fourth century, Germanic tribes were pouring into central and Western Europe from their eastern homelands. These losses of territory, which continued into the fifth century, resulted from a weakening of the overall defensive capabilities of the Western Roman Empire against the greatest population migrations the Empire had faced in its history. The Western army was not large enough on its

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4 Although recent evidence suggests the Empire did not suffer a decline of men under arms (see H. Elton, *Warfare in Roman Europe AD 350-125*, pp. 89-127), the sheer mass of invading groups over widely spaced borders made resistance to them virtually impossible.
own to form an effective barrier between the mostly Germanic tribes and the more prosperous lands under Roman control. Most prominent among the populations pushing westwards were the Vandals, Goths, Franks, Burgundians, Angles, and Saxons. Political changes in Western Europe were a direct outcome of immigrations of these peoples originating from Eastern Europe and the lands north of the Black Sea. There were political and social ramifications not only for the immediate areas of incursions, but for all of Europe and the Mediterranean as well. These immigrations did not result in simply a larger, romanized population. Instead new political entities with mixed cultural influences were formed. Some of these political entities lasted a century or longer, and shaped the future social and cultural developments in Europe and the Mediterranean for more than a millennium.

The newly settled Germanic and Scythian\(^5\) groups had for generations lived and traveled in the forests, mountains, coasts, and river valleys in lands east of the Rhine and Danube rivers. Here, organized in tribal confederacies, they had warred amongst themselves, other tribal groups, and with neighboring states. Contacts with the Roman Empire hastened their development of more hierarchical social and political systems, which in turn increased incentives for them to organize effectively. After these Germanic groups were able to seize control of former Roman areas, their developing social and political systems were applied to the management of small states.

Once in power the Germanic rulers were challenged with greater economic, political, and technological complexities than they had previously known. Among these was the utilization of ship technology, with which many had heretofore had limited experience. At once, they encountered problems of maintaining economies dependent on shipping and states linked by seaways, as well as of fighting battles and transporting armies on the sea. The mastering of sea technology was a great imperative for the Vandals, Franks, and Goths, as the Eastern Roman Empire had long been adept in sea trade and warfare. Without due attention to the important sector of water transportation, these nascent states would surely have seen their economies suffer and their sovereignty threatened from overseas powers. For example, the Angles and Saxons possessed well-established water transportation technologies that were crucial in their effort to seize and control new territory. Likewise, it was a matter of survival for the new Germanic and Scythian states during the fourth to seventh centuries to master shipbuilding and ship operating technologies and apply them proficiently. With disparate cultures now possessing these new elements of technology in the Mediterranean, the trends in ship and boat construction underwent further and more rapid transitions.

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\(^5\) In this study, the designation of "Scythian" refers to the Gothic groups that formed the Ostrogothic and Visigothic kingdoms: H. Wolfram, \textit{History of the Goths}, pp. 21, 27, 44, 53, 66, 107-109, 129-134, 176, 265; Procopius, \textit{History of the Wars, I}V.8.5.6.
CHAPTER II
DISCUSSION OF EVIDENCE

Introduction

In analyzing the role of water transportation in the various cultures of Late Antiquity, I have used three types of evidence: archaeological, historical, and iconographic. Each type has its own strengths and weaknesses, presenting its own particular problems to the investigator in its application. None of them is necessarily superior to the others. Instead each type addresses different questions with varying degrees of effectiveness. The dilemma for the researcher is to use each type of evidence properly, and to appropriately extract the maximum amount of information without overstating the data. Through a combination of the three types of evidence, a good representation of the ship technologies utilized by the Roman Empire and the Germanic and Slavonic kingdoms, along with their applications in trade and warfare, is possible.

Archaeological Evidence

Numerous shipwreck sites from the Roman Imperial and Late Roman periods have been excavated over the past several decades. Although there has not yet been a definitive ‘Vandalic’ or ‘Ostrogothic’ shipwreck excavated, there are excavated ships that probably had frequented the ports of and carried goods originating from these kingdoms and the Empire. From these ship remains found throughout the Mediterranean and continental Europe (hereby referred to as Europe for convenience) it is possible to gain an understanding of the general construction and techniques active in shipbuilding. Archaeological material also contributes to an understanding of the accompanying economic, technological, and cultural milieu. The strengths of the archaeological evidence included in this analysis lie in the areas of technology, decorative motifs, and use of materials. It effectively addresses the question of distribution patterns and cultural influences as well. Because the clearest and most unambiguous evidence of shipbuilding technology is derived directly from ship and boat remains, archaeological material is given primacy among the three types of evidence in this specific area of research.

In my analysis, I have handled archaeological evidence in two different ways. Artifacts such as pottery, settlement sites, and architectural remains have already undergone primary analysis by other scholars. Their conclusions are used to support statements in the present study about technological, economic, and political aspects of the Roman Imperial and Late Antiquity periods. Shipwreck sites contribute to a more comprehensive, general analysis of their collective raw data. The primary investigators have recorded in detail the physical remains and likewise offer their conclusions and hypothesis regarding this data. My goal is not to review the conclusions of each individual site based on the raw data it offers, but to combine the data of numerous sites in order to draw new conclusions about
trends and changes. These trends are then placed into the social, economic, and cultural contexts of the period derived from archaeological and historical evidence.

When working with data from a wide variety of sources, the mode in which they were reported and their nature often differ. In order to make comparisons, primary data were often extrapolated from that given in a report. For example, if the space between mortise-and-tenon joints was given, and the average length of the mortises is known, then it is a simple matter to obtain an average center-to-center spacing by adding the two dimensions together. When dimensions are given in the form of ranges, I have used midpoint values (for example, for overall vessel lengths and beams) for quantitative analysis. Where the dimensions of a timber, such as the keel or frame, varied, either an average of the maximum and minimum dimensions or the predominant dimension was used depending on the timber's shape. A timber may, for instance, have a rather consistent width for the majority of its length and then taper suddenly at its extremity; thus to utilize an average for its maximum and minimum widths would be misleading. Wherever dimensions were not given in the text of reports, but scaled drawings or plans were provided, dimensions were measured from these drawings as accurately as possible. In such cases every effort was made to use an original publication as opposed to photocopies to avoid distortions.

No single ship will represent what could be described as the 'typical' design or construction of ships throughout the vast area of Europe and the Mediterranean, just as no house structure or sword was typical. Although similar threads of general technology existed, a variety of applications of the technology was possible. Every ship was born out of varying circumstances unique to its design, construction, and use, as well as the suite of technological options available to the designers and builders. One must also consider the active forces of the human imagination, innovation, and creativity when engaged in the fabrication of tools to solve problems. After all, ships are but tools, each designed to solve various, and sometimes novel, sets of problems. Hence, it is not only necessary to understand the general construction approaches and techniques, but also the uniqueness of their applications by different groups of people. However, a comparative analysis of both the technological options utilized in a given period and their change over time can be elucidated.

**Historical Sources**

There is a wide range of historical accounts used in my analysis, including histories, panegyrics, and letters. They include the works of Vitruvius and Livy from the early Imperial period; Ammianus Marcellinus from the fourth century; Procopius, Cassiodorus, Isidore of Seville from the fifth and sixth centuries; and Bede from the eighth century. A fundamental problem facing the researcher is the personal biases, agendas, informed nature, truthfulness, and writing skill of the ancient author. For example Alciplthon, writing at the beginning of the third century, must be carefully used, since he often draws from much earlier historical events. Likewise, there is a danger with Aelian, writing in circa 200, in that he often takes references from much earlier writers and periods into his writing. Procopius relates to us the
events in the Court of Justinian at Byzantium and of the early-sixth century in the Mediterranean world in both panegyric and critical works. To address these problems, one must rely on scholars who have devoted much time and effort to accurate translations of the disparate works and who provide appropriate warning and explanatory notes for them. I do just this in my analysis, relying on scholarly translations in lieu of effecting a new translation and analysis of each work.

Furthermore, an attempt is made to rely more on passages concerned with more observational and descriptive accounts of physical items, events, and manufacturing processes, rather than with dialogue, personal relationships, and beliefs. The assumption is that these references, although still viewed with a critical eye, have a greater degree of reliability due to their being somewhat less subject to exaggeration, bias, and use for propaganda purposes. However, there is always the problem that authors were often unfamiliar with the technology they were describing, but their accounts have the advantage of being comparable to the archaeological record. In all cases where archaeological and historical evidence overlap, I have attempted to compliment each with the other, hoping to create both a larger corpus of data and a more detailed picture of ancient technology. Wherever there are distinct contradictions in the two sources concerning aspects of shipbuilding technology, deference is given to the archaeological evidence since it provides an actual application of the technology.

I have relied on secondary historical sources in addition to primary sources for the setting of the socio-political background and context. For example, these secondary sources are heavily relied upon for interpretations in Chapter III: Historical Background, where large sections of history and material culture are summarized. A concerted effort was made to cite the most recent works, and multiple works are noted wherever possible.

*Iconographic Evidence*

Iconographic evidence, technically a subset of archaeological evidence, is one of the more difficult forms of data with which the researcher has to contend. As with the authors of written sources, there are issues of the artists' ability, stylistic canons, and knowledge. In addition, works have various contexts and purposes, whether as part of an attempt to reinforce the authority of the state or simply to decorate a triclinium. Different media, materials, and types of objects decorated also affect the representations. For example, more detail could be included on a large arch relief than on a small coin motif.

There have been numerous attempts by scholars to examine a single work, or element from it, and draw conclusions about the state of some aspect of ancient technology. In effect this method is treating the works as photographs from known historical contexts. Such attempts are inherently subject to mistakes, whether due to artistic omission or misrepresentation, and have very little scholarly merit. Unfortunately, few ancient artists were engaged in producing technical scaled drawings. Nor were they bound by the constraints of reality, physics, or mechanical feasibility. Hence, iconographic evidence is
subservient to archaeological evidence in my analysis whenever there is direct conflict. It is used, however, to generally bolster and fill out the archaeological record, especially for areas where artifacts are lacking, such as vessel rigging and decoration.

I have made several assumptions when utilizing iconography. Each work is considered to have been based at least partially in reality, the artists not creating completely imaginary works that could not be found in their contemporary world. It is possible that some representational elements may, of course, be partly imaginary or anachronistic in nature. I have further assumed that the representations are those of watercraft that were contemporaneous with the artists or at least nearly so. The obvious dilemma here is the possibility that the artist used a more ancient representation in order to convey a specific notion, such as the prestige of past glories. Also, the artist may have used a pattern or style that had deep historical roots. It is hoped that through an aggregate analysis of representations, such instances will be moderated or shown to be anomalies. It is also assumed that artists typically represented a minimum number of features when depicting a ship or boat. The artist may not have faithfully represented, for example, every rigging line, but some of the main lines would have been indicated. Thus, the artist has produced a basic illustration of rigging in general; and, one would hope, did not at the same time create lines that did not exist. Some elements are more likely to be reliably represented that others; the number of masts or bow shape are, for example, assumed to be more faithfully depicted than every individual rigging line. Finally it is assumed that no proportional or size information can be readily deduced from any iconographic representation, regardless of the apparent realism or skill in execution. To make such deductions would place an undue (and unwarranted) burden on the artist to produce a technical drawing. Such a use of the iconographic material would be inherently illogical and misleading.

With the above assumptions in place, I have analyzed the iconographic evidence as a single body of data rather than making a separate analysis for each representation. Each depiction is therefore broken down into discrete component elements that are charted for their presence or absence, number appearing, or placed into nominal descriptive categories. From this breakdown of elements, frequencies of occurrence can be compared by set time periods. Making the assumption that artists produced relatively contemporary illustrations, and that works of art are often difficult to date precisely, I have divided the iconographic data into three broad time spans where enough examples permit. I hope in this way to ameliorate substantially the problems that would occur were the representations analyzed on an individual basis.
CHAPTER III

HISTORICAL BACKGROUND

Introduction

Since the development and use of water transportation technology is set within a cultural context in this research, it is essential that a brief outline of the major socio-political events of the period be provided. The focus of this synopsis will be on the major cultural groups involved, for it is their needs and abilities that are most germane to a discussion of ocean and river vessels. Of course many events and issues will have to be omitted in such a summery account. Many works are found in the bibliography that can provide the reader with a more comprehensive chronicle of events for the period or individual cultures. Notable survey works include Averil Cameron’s The Mediterranean World in Late Antiquity AD 395-600, Klavs Randsborg’s The First Millennium AD in Europe and the Mediterranean, and A. H. M. Jones’ The Later Roman Empire 284-602. Works such as these are excellent examples of both an examination of larger trends through a compilation of archaeological evidence and the joining of historical references with archaeological material.

The Later Roman Empire

Political overview

The third century was ushered in under the Emperor Septimius Severus (196-211). He inherited a large territory to govern, procured primarily through the efforts of the Emperors Trajan (98-117) and Hadrian (117-138) a century earlier. By his accession, the consequences of this expansion, namely the constant efforts to turn back Germanic groups attempting to push their way into Western Europe, were in full motion. In Britain, the relatively peaceful situation since the construction of the Antonine Wall ended with the outbreak of war in 208. During a three-year battle, culminating in Severus’ death, the frontier in Scotland returned to Hadrian’s Wall. The next three emperors, Caracalla, Severus Alexander, and Maximinus, were all faced with both Germanic incursions and a renewed Persian military vigor in the East.

Often referred to as the “Years of Anarchy”, the period between 250 and 270 was a time of political, social, and economic turmoil in the Roman world, which witnesses a parade of claimants to the Roman Imperial throne. Both exterior and interior threats to Roman power arose, and exacerbated the economic problems of the Empire. The year 260 marked a crucial point in the formation of later Roman Imperial history. In the East, Rome’s relations with the Persian Empire had been peaceful since the treaty made by Philip I in 244. This treaty was broken when Valerian (253-260) was trapped and captured by a Sassanian army in 260 and died shortly afterwards. Following this setback in the East, the rulers of Palmyra seized power in Mesopotamia, Syria, and eventually Egypt.
Further to the west, the Balkan and Rhineland areas were also in a state of instability. The Goths were firmly entrenched in the Balkan territories after their defeat of the Emperor Decius in 251. Along the Rhine, lands in Germany were still reeling from the previous year when Germanic tribes, including the Franks, overran the border. In the wake of this invasion, a military commander in Gaul, Cassius Latinus Postumus, was proclaimed Emperor by his troops, and after conflicts in 260 he established himself as ruler of Gaul, Britain, and parts of Spain. The subsequent ‘Gallic Empire’ survived until 273 when it was duly reincorporated into the Empire.

The debasement of coinage had reached a critical level during the 260s, reflecting the Empire’s currency problems, inflationary woes, and difficulties financing military operations. With a loss of territorial control there was an associated loss of revenues for the central Imperial administration, although internal investment by the regimes of these temporarily independent provinces was beneficial for their territories in lieu of Imperial investment.

Despite the economic and political battering of the 260s the Empire survived and remained largely intact into the 270s. Out of the chaos of the later third century arose the Emperor Diocletian. His reforms in the 280s and 290s laid the foundation for the eventual circumstances of the fifth century that lead to the fall of the Western Empire. Diocletian reorganized the Imperial administration into four Prefectures, each comprised of twelve dioceses, and each of these divided into reorganized provinces. The chain of command followed these territorial divisions and relied ultimately with the senior Emperor himself. Diocletian’s reorganization of the military included the construction of forts and postings along the limita, a more responsive cavalry, and an overall increase in the number of troops. Although the army’s size remained relatively consistent during Late Antiquity, certainly not doubling or quadrupling under Diocletian as many historians have suggested, it did remain the largest expenditure for the Roman government throughout the period. Military expenditures were also large among the Western kingdoms of the Vandals, Ostrogoths, Franks, and Visigoths. Inherent in the military expenditures was the organization of the feeding and provisioning of troops. The governments on which this duty fell accomplished this task through a shifting combination of coinage and in-kind payments. As the latter became more important over time, water transportation became increasingly crucial in the concentration and redistribution of foodstuffs and materials.

Constantine (324-337) continued the reforms of Diocletian (284-305), formalizing the military into static forces along the frontiers and stationing mobile forces towards the interior. Constantine had great military success against Germanic groups on the borders, and he increased the integration of Germanic warriors into the military. The later emperors Julian (316-363) and Jovian (363-364) encountered a rising Persian threat and subsequently lost Roman territory in the East, while the brothers

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1 Diocletian’s reforms, much like all Roman Imperial edicts, were reactions to situations out of Imperial control; hence the laws cannot be equated with the a narrative on current events of the period.
who followed Jovian, Valentinian (364-375) and Valens (364-378), divided the rule of the Empire between East and West. In the West, most of Valentinian’s reign in the west was consumed with repelling invasions along the Rhine, in Britain, and Africa. Consequently, there was a great deal of fort construction along the frontier regions during his reign. Meanwhile, Valens in the East had a generally less contentious reign until his fateful dealings with the Goths in 376 and his subsequent defeat at the Battle of Adrianople in 378.

Throughout the rest of the fourth and early fifth century the Empire saw continual losses in its western territories, as it became less able to resist Germanic incursions. For example, the usurpation of Roman territory in Gaul by Magnus Maximus (383-388) tied up military resources in Northern Europe and provided Germanic groups the opportunity to make inroads into the western portion of the Empire. Historians have often tended to define ‘decline’ of the western Empire as a territorial loss, particularly from an economic point of view due to the loss in tax revenues. From a Roman standpoint this is probably the case, but it is only one culturally specific perspective, and not one of the more important or valid ones. From the viewpoint of the Germanic and Scythian groups, this was a period of economic boom as they gained control of territory and sources of tax revenues, access to resources, and control of capital assets. On the individual level, people under the rule of these kingdoms were being taxed in a relatively unchanged manner, although the system was now on a smaller scale and the rates may have been different. This takeover of western territories by Germanic groups can also be characterized as a movement toward equilibrium between the Empire and the surrounding cultures. Merely because the Empire was able to conquer and hold most of Europe for a couple of centuries does not indicate that the situation was a stable. Despite the fact that the Empire was able to maintain control over most of Europe for several centuries, this union was tenuous, and with the newly won control of lands, the Germanic and Scythian tribes realized the advantage of maintaining their own political hegemony in the face of Roman attempts at military assimilation.

**Economy**

Much of the early work done on the Roman Imperial economy through the 1970s formed an overarching model that depicted the economy as agriculturally based with some exchange of elite goods. These models allowed little activity within true market systems, such as urban industrial production, and downplayed a wide variety of goods being exchanged outside of their local production areas. Due to the wealth of information provided by archaeological evidence since the 1970s (especially from underwater sites), a modified picture is emerging where there is more emphasis given to more sophisticated market mechanisms operating in the Roman economy.  

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There is no doubt that the economy throughout the Later Roman Empire, and into the seventh century, was overwhelmingly agrarian based, of which most of the production was consumed by the producers. Throughout this period the majority of land under cultivation was owned by those in the wealthiest sectors of society and worked by tenants or slaves. There is a general ruralization of the economy since large villas with vast land holdings dominate it. Until the mid fourth century, the Roman Empire was able to maintain the integrity of its vast empire although great expenditures on defense financed by this agrarian economy, but outside pressures were soon to end its extensive territorial holdings.

Despite experiencing political and economic problems, the economy of the Later Roman Empire enjoyed surplus production, which, in turn, gave rise to redistributive mechanisms that played a significant role in the economy, and it was the principal economic role of the Imperial government to plan, implement, and administer a redistributive system. The government faced two main problems, supplying the army and feeding the masses in the larger cities, both of which were essential for an emperor’s survival as leader. Foodstuffs such as wine and olive oil, and especially grain represented the largest portion of government-sponsored trade. These foodstuffs were collected from all over the Imperial provinces in the form of a tax in kind, the annona, which was redistributed from surplus to deficit areas within the Empire. Organization of the annona involved the collection, transportation, storage, and redistribution of bulk cargoes. Much of the infrastructure, bureaucracy, and some financing for this system were provided by both local and central governments. However, private individuals handled a significant amount of the transportation and associated costs. Their costs were defrayed in part by a governmental contract that entitled them to various exemption benefits. Here, the Imperial redistribution system was directly stimulating the transportation sector of the economy. Indirectly, it fostered long distance trade, as goods for sale by private individuals often piggy-backed on annona shipments. Imperial policy could have far reaching implications for private merchants. Diocletian’s military and tax reforms that regionalized and increased the scale of the annona shipments to the army, for example, affected the directions, number, and frequency of trade routes.

Another specific area of government economic stimulation is found in the mining industry and the associated minting of coinage. Gold and silver were transported from source areas to central locations where they were struck into coins. Coinage was then used as payment to the military and for other projects such as building programs, both of which effectively redistributed these precious metals. As

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4 Based on this predominantly agrarian economy, some scholars maintain that the basic economy, material culture, and population demographics changed little during the first millennium AD. This pertains and is owing to the vast majority of the population having been agriculturalists and to a lesser extent merchants, craftsmen, and soldiers. From the viewpoint of this long historical period, most individuals of the first century would not have felt out of place in a similar socio-economic situation in the tenth century. K. Randsborg, *The First Millennium AD in Europe and the Mediterranean: An Archaeological Essay*, pp. 8-41.
coins were struck from metals that had intrinsic value, they also served as a store of wealth for individuals. The value of these metals increased over time, often significantly in a short period of time, making gold and silver good stores of wealth. However, the debasement of coinage diminished the rôle of coinage as a store of wealth just as it decreased the value of denominations.

The management of monetary instruments provided one of the greatest impacts on an economy's market systems due to the innate characteristics of money. Archaeological and written sources suggest that coinage was a widely utilized method of exchange throughout the Imperial period. During the early Empire the standard coin was the silver *denarius*. The silver content of the *denarius* decreased over time, becoming merely a bronze denomination dipped in silver by the later third century. For subsequent centuries, Constantine's monetary reform provided a more stable system of coinage based on the gold *solidus*. Although earlier debasement of the *denarius* caused inflation, it does not appear that it had tremendously negative effects on the economy since coin finds indicate that circulation remained active throughout the Imperial period. It is true that many smaller copper and bronze denominations fell out of use over time, but the use of coinage as a whole did not fall out of use. The Imperial approach toward active monetary policy was virtually non-existent since the methods of managing monetary instruments other than debasement were unknown. Typically, decreases in the market value of money were dealt with by an increased production of coinage, often with a coin that was further debased. This only served to exacerbate the problem. One positive indicator for the functioning of market systems in the Roman Imperial economy was this very reaction to monetary velocity. Because private exchange markets were active and utilized coinage in their operations, the associated inflationary reaction occurred. Decurions gained and kept social prestige and political power by building the theaters, aqueducts, amphitheaters, and baths that characterized the landscape of Roman Imperial cities. Hence the wealth of the decurions was redistributed and can be argued to have been exchanged for social advantage. With the rise of Christianity and church construction, and the subsequent decrease in traditional public investment, however, there was some decrease in the overall public benefit from construction projects, and thus a decrease in redistributed wealth.

The economic repercussions of the Emperor and wealthy decurions financing construction projects were widespread. Both skilled and unskilled supplies of manpower were required, and depending on the scale and nature of the project, the composition of local and outside labor utilization would vary. Thus, payments stimulated the exchange sector of the economy. Materials required for these building projects were often transported great distances across the Empire. Tesserae, marbles, and hardwoods, for

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5 Monies are portable, fungible, and divisible into denominations.
6 Future work will help to clarify the role of coinage in the Roman economy, and scholars are offering an ever-increasing number of insights. Not only are questions about the degree of monetarization in the economy addressed in modern studies, but questions concerning social relations and periods of political stress as well. Greene, *Archaeology of the Roman Economy*, pp. 45-66.
example, were commonly moved over great distances by land and sea. The extraction of most resources and their transportation were typically handled by the private sector. Thus unlike the extraction of precious metals for coinage, there was a greater potential for market forces to act in these trade industries by, for example, competing suppliers providing incentives for maintaining cost effective operations. Archaeological excavation has provided good insight into the changes in building usage and construction within an urban setting that reflect the downturns and up trends of local economies. Additionally, archaeology has provided evidence for the nature of the transport of building materials throughout the Mediterranean and Europe.

Specific building projects such as roads, canals, and port facilities acted to decrease the overall cost of transportation within the Empire. Some protection from piracy and brigandage facilitated the transport of goods and kept operating costs under control. Thus, the buyers and sellers were attracted to harbors within Imperial domain where they could conduct their business in relative safety. Furthermore, the very existence of a geographically vast unified Empire brought items from disparate cultures into contact, which created demand for goods not found locally or, alternatively, spurred the development of new industries to develop such goods.

Government involvement in the form of economic legislation and protection also benefited the overall economy notably in the development of contracts, cooperative economic ventures, and the clear establishment of liability in many cases of loss. Generally, such an environment fosters the consolidation of capital for private ventures to a greater degree than might be found in less economically centralized communities.\(^7\) Within the safe Imperial boundaries a broader degree of products and services were redistributed and marketed on a greater geographic and quantitative scale than prior to the Empire, with some associated increase in the ability to manage risk and investment capital. However, regulated trade was not necessarily governed by the same market principles that we observe in modern economies. During this period there were two basic types of state contracts: those regulating military supplies and those concerned with the transportation of produce from imperial estates. This system of private contractors operating under favorable tax exemption laws produced a mix of state and private cargos.

During the period of the Late Empire, a principal component of long-distance trade in the Mediterranean was the organization of the *annona*. The *annona* in this period was the state funded shipments of foodstuffs from the provinces to the administrative centers of the Empire, and it often entailed the attempted fixing of prices on these foodstuffs. The foodstuffs were primarily intended to supply the army, state bureaucracy, and the population of major urban centers, Rome being foremost among them. However, some *annona* commodities were also sold on the open market or shipped to cities in times of famine. Until the founding of Constantinople as a second capital in 330, the principal *annona* shipments to Rome were from North Africa, Sicily, and Egypt. Under the reign of Commodus (180-192),

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a transport fleet for the annona, the _classis Africana_, was stationed in Carthage to handle the task. It must also be noted that the some sources of the annona were from the estates of government officials who made decisions on their purchase. This helped to provide a secure source of income for many wealthy, land-owning senators.

The increasingly large estates maintained by senators were also an important factor in the stimulation of market forces. These estates usually possessed large, extravagant living quarters centered on vast blocks of agricultural lands. Produce from these lands were sold within the state system and provided sizable incomes for their owners. The Roman diet typically included wine, olive oil, and _garum_ (or other fish sauces) irrespective of where individuals were living within the Empire. With large armies stationed over a vast amount of territory, the produce of these estates had an insatiable market. On top of the staples that were transported, fruits, vegetables, meats, nuts, and spices were also demanded by estates and military posts in all provinces. In addition to foodstuffs shipped within the state system, a wide variety of foodstuffs were also transported overseas to satisfy the exotic tastes of wealthy and powerful individuals.

In addition to foodstuffs, a wide variety of exotic building materials (marbles and hardwoods), decorative items (dyed cloth, metalwork, sculpture, tesserae, glass, pottery, exotic flora), and personal items (finewares, utensils, jewelry, unguents) were imported in order to maintain the material necessities and social standing of aristocrats and military officers. Although many of these represent items of luxury trade, each required some form of resource extraction, preparation, working, and/or manufacture, as well as transportation from producer to markets. Archaeological work on villa, military, and production sites has been crucial in discovering the wide variety of luxury goods distributed throughout these Imperial markets. Individuals competing in this luxury trade greatly stimulated the economy.

Often disproportionate importance is given to aristocratic ‘gift exchange’ in the Imperial and Late Roman periods. It is often characterized as existing in a mutually exclusive and dominant relationship to that of individuals seeking markets for their surplus production. On a fundamental level each landowner produced a particular amount of oil, wine, fish sauce, grain, etc. and had to determine the appropriate quantities to allocate for personal and estate consumption, taxes, selling in the market, and ‘gift exchange’. It is unrealistic that the majority or even a great quantity of production was given in gift exchange to other wealthy individuals. Wealthy individuals were landowners for a reason: land gave them sustenance and income, both in goods and coinage. Agricultural products had to be transformed into a suitable medium, usually coinage, which was essential to purchase the wide variety of luxury items demanded, to finance capital investment for projects, and to pay wages. Prestige was crucial to maintaining high social status and was gained through an appearance of self-sufficiency, the funding public works, and the donation of gifts. The few in Roman society able to shoulder these costs could only do so because they were able to accumulate surplus within the market system, and use this wealth as capital for investment.
Operating an estate required working capital for labor acquisition and upkeep, infrastructural buildings and their maintenance, transportation costs, acquisition of raw materials and finished goods, and the purchase of exotic and luxury goods. A landowner could not rely on these demands being met in the appropriate amounts as needed solely through a system of gift exchange. Nor were barter systems reliable due to the inherent unpredictability of encountering individuals with mutually satisfying trade items at the appropriate time and place. Barter systems were typically operating on a smaller scale, and involved basic foodstuffs and materials that were exchanged within scheduled and ordered systems that functioned to overcome some of these difficulties. In addition, wealthy landowners needed currency for travel, as a means of storing wealth, and for numerous urban transactions.

Undoubtedly, gift giving did exist and was no doubt extolled in written accounts because of its conspicuous nature and to further its prestige effect. However, it was at best a minor element in the general scheme of Mediterranean and European economies. Items were primarily acquired either by direct trade (surplus produce traded for needed materials) or indirect trade (conversion of surplus into currency and subsequent purchase of needed items). The exciting archaeological finds containing items of precious metals and gems, foreign objects, and exotic coins inspire much attention by archaeologists in regards to the exchange of prestige goods. It is likely that these types of items represent gift giving and conspicuous consumption, but a handful of items collected over a lifetime by one in every thousand individuals do not truly represent the primary economic mechanisms at work, or the quotidian activities of individuals. Such prestige items are often useful for identifying the geographic and quantitative nature of economic patterns, as well as the regional connections through which the main economic mechanisms operated. The vast majority of archaeological finds represent the trade of foodstuffs, materials, and finished goods that comprised the bulk of economic activity.

By the later Empire, the idea of gaining prestige through munificence was already giving way to accumulating personal fortunes. This process can be seen in the East, where there was a rise in the avoidance of curial responsibilities by the wealthier members of a city, and the associated legislation that attempted to lock them into such duties. In the Western kingdoms prestige was more often gained through association with the court. Hence, it was left to the king and his local officials to fulfill the role of organizing city improvements. It appears that the less stable world of competing states in the fifth–seventh centuries put an even higher premium on wealth as opposed to prestige for social mobility and status.

Additional support for market systems operating within the economy can be found in the level of urbanization in the Roman Empire. Given that the vast majority of people lived in a rural setting, there were nevertheless thousands of cities and towns throughout the landscape (concentrated more in the East than West). Most would have had only a few hundred or thousand people in the immediate surrounding area, but there were large cities such as: Rome, Milan, Trier, Carthage, Constantinople, Ephesus, Antioch,
and Alexandria. Basic economic theory stresses that urban settings tend to have more job specialization, less self-sufficiency, higher levels of dependant individuals, and thus a greater need to acquire goods from others through market systems. Archaeological and written evidence for job and industry specialization, concentrated living conditions, construction encroachment, compartmentalization of pre-existing structures, and specialized sellers is overwhelming.\(^8\)

Overall, the Imperial administration seemed to view the Roman economy as a source for supporting the government and, most importantly, the military.\(^9\) It also appears that the general view considered land, as opposed to commerce, as the primary source of wealth, although this is to some degree a false dichotomy.\(^10\) Most tax codes and revenues, including the tax reforms of Diocletian, were concerned with territorial holdings. Furthermore these taxes were to be paid in greater proportion by the poorer than the wealthier segments of society, since exemption from taxes were perceived as a privilege of high rank.\(^11\) Monetary policy was limited to keeping up with inflation with brief respites such as that lived during Constantine’s reforms. However, after introduction of the gold solidus, denominations in other metals shifted in value.

**Development of the Eastern Roman Empire**

Upon the death of Theodosius (392-395), the Empire was to be forever split between East and West, with the West destined to be overrun within a century. Numerous Germanic and Scythian groups were forcing their way onto western Imperial lands driven in part by the advancement of the Huns. Throughout the mid-fifth century the Eastern Emperors had placated the Hunnic leaders with gold payments, while the West engaged in cooperative operations with the Huns. Not only were western territories lost, but kingdoms arose on these lands during the fifth century: the Visigoths in southern Gaul and later in Hispania, the Vandals in north Africa, the Franks in Gaul, and the Ostrogoths in Italy. Eastern Emperors had to deal with these newly formed Slavonic and Germanic kingdoms whose rise effectively relegated the Empire to the eastern Mediterranean, the southern Black Sea, and the southeastern Balkans. Various treaties were negotiated with these kingdoms with an eye kept eastward on the traditional Persian threat. In addition to foreign policy dilemmas, domestic political and religious problems were confronting the Eastern Roman Empire. For example, religious turmoil is evident from the controversies arising

\(^8\) Archaeological evidence has shown that during the latest Imperial period new construction often encroached on the largest houses, and shops became segmented into smaller multi-dwellings. These phenomena have often been stated as evidence for a decline in urban populations and in urban investment. *A Cameron, The Mediterranean World in Late Antiquity: AD 395-600*, pp. 159-166.

\(^9\) The military system also furthered the economy. Trade was fostered to a degree by the establishment of *coloni* in areas of resource extraction or finished goods production to help ensure Roman control of resource areas and entry into markets.

\(^10\) The maintenance of large or small landed estates was dependent on an ability to derive income through a market sale of produce; agricultural production and trade components of a single economic system, and the differentiation between them was more culturally than economically based.

\(^11\) Taxes that were not graduated on the basis of income level were thus regressive in nature.
during the Council of Ephesus in 449 and again during the Council of Chalcedon in 451. Despite growing troubles with the west and constant theological turmoil causing unrest, there was economic prosperity and growth in later fifth century, notably under the Emperors Leo (457-474) and Zeno (474-491).

Changes in the Mediterranean and European political landscape naturally affected the Eastern Empire’s economy. With the Vandals occupying North Africa, Egypt was relied upon to supply food and other resources associated with the annona to Constantinople and the Eastern armies. However, trade did continue with the west and by the sixth century the church was playing an important role in the economy as well. Special officials, known as negotiatores, were attached to royal courts and abbeys of both the Eastern and Western Empires who organized supplies as well as marketed surpluses. Under Justinian (527-565) negotiatores had responsibilities as important the overseeing of grain supply for Constantinople and of handling the financing of military contracts. Some monasteries and abbeys that produced surpluses were conducting private open-market trade, as well as the redistribution of foodstuffs. Furthermore the negotiatores, shippers, and merchants that were attached to many churches could benefit from special tax exemptions.

The economy of the Eastern Empire continued to benefit from the circulation of money in purchasing goods and services. During the fifth and sixth centuries, the primary units of coinage in the Eastern Empire were the gold solidus, copper nummus (equivalent of the denarius), and the copper follis. Coin values were tied to a gold system whereby a nummus equaled $\frac{1}{7200}$ of a solidus, and the follis equaled 1000 nummi. Gold coinage (solidi, semisses, tremisses) remained unchanged for the better part of the sixth and seventh centuries, with only a single serious debasement occurring in Italy after the seventh century. After a short absence, a mostly silver denomination reappeared during the seventh century in the form of heavy hexagrams struck in the East between 615 and 680. The system of copper coinage persisted through the reign of Emperor Phocas, as did several other smaller denominations, but collapsed under Heraclius with only the follis surviving, albeit significantly debased. Overall, the number of mints decreased in the seventh century; Antioch and Cyzicus were closed with the accession of Heraclius,

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12 Controversies typically arose from struggles for power within the church between the sees of Constantinople, Rome, Antioch, and Alexandria.
12 Cameron, Mediterranean World, pp. 78-80.
14 Jones, Later Roman Empire, pp. 894-904, 907-908, 912.
15 Although these denominations were common throughout the entire East, the primary coin used in Egypt was the dodecanummi, which was equal to twelve nummi.
16 These are approximate fifth-century values. Jones, Later Roman Empire, pp. 440-441.
Thessalonica was shut down in 619/620, and Nicomedia was closed in 627. Surviving mints included: Constantinople, Syracuse, Cagliari (Sardinia), Ravenna, Rome, and Naples.\(^{18}\)

Politically, the Eastern Empire in the first half of the sixth century, as well as the rest of the Mediterranean world, was dominated by the campaigns of Justinian (527-565). Under his general Belisarius, Roman forces conquered Vandal North Africa in 533, Ostrogothic Italy in 552, and carved out a position in southern Hispania by 554. During this western effort Persia was active on the Empire’s eastern frontier, which required several campaigns and treaties to keep them in check. For example, a treaty with the Persians in 551 allowed Justinian to concentrate his effort on the Ostrogoths.

Throughout the rest of the sixth century Eastern Emperors were faced with more territory to defend with considerably reduced finances and manpower than Justinian had earlier enjoyed during his campaigns. However, in the following years Imperial territories were lost. In Hispania the Visigoths proved resilient and relegated the Romans to a strip along the southern coastline that required considerable expenditures of resources to maintain. Additionally dangerous new enemies presented themselves such as the Avar Khanate that swept into the void left by the fall of the disintegrating Hunnic Empire. Revolting soldiers, suffering in the Balkans while attempting to keep the Avars in check, killed Maurice (582-602), after which the Avars overran and ravaged the Balkans. With the Slavs quickly following in the wake of the Avars, the Balkans were effectively lost to the Empire by 626.

Other Imperial territories were lost as well in this period. Further east, the Persians took advantage of the Empire’s troubles to conquer all of Syria, Palestine, and Egypt by 616. The Emperor Heraclius temporarily regained much of these territories by 629 and undertook great economic and military reforms to try and maintain the Empire’s holdings. The Empire did fail to hold their territories in Hispania, however, and was permanently ejected by the Visigoths in 624. Additionally, much of the hard gained territories in Italy were lost to the Lombards in the north and the newly independent duchies in central and southern Italy. Costly battles with the Persians over territories combined with the loss of other lands by the Romans left both powers weakened by the 630s. Taking advantage of this weakness, the Arab Caliphate quickly subdued then the Eastern Imperial and Persian forces. The Arabs had taken Palestine by 636, Mesopotamia by 637, Syria and Egypt by 640, and by 651 the rest of North Africa was subjugated. Mostly isolated to Anatolia in the mid-seventh century, the Eastern Empire embarked on a period concerned more with survival than imperial expansion.

**Gothic Origins**

As a prelude to a discussion about the Gothic kingdoms, a brief outline of their history prior to their incursions into the Roman Empire is helpful. In discussing these peoples during the first to fourth centuries the term ‘Goths’ was not applicable to a distinct socio-political entity that is archaeologically

\(^{18}\) With territory and resources on the decline, the output of the surviving mints appears to have decreased: Ibid., pp. 6, 36.
recognizable. Rather it refers to groups of individuals under various kings with similar cultural traits that may or may not have considered themselves as a single political or ethnic entity. It is these groups that would by the late third/early fourth centuries coalesce into socio-political forces within the Empire and play a significant role in Western history. Furthermore, it is not accurate to speak of 'Visigoths' and 'Ostrogoths' before the fifth century, as these two groups of Late Antiquity were formed out of at least five different Gothic groups. The 'Visigoths' were comprised for the most part of the Tervingi, the Greuthungi led by Ermenaric, and the Goths led by Radagaisus, whereas both the Goths led by Amal and the Goths of Theodoric Strabo were referred to as the 'Ostrogoths'. Numerous contingents of other tribes were also included in the ranks of these Gothic groups.19

There is poor and contradictory evidence for placing the Goths in Scandinavia, where historians have often assigned their original homelands before the first century.20 Archaeology has provided a better picture for Gothic origins in recent years, suggesting that the Goths of Late Antiquity arose from the Wielbark culture centered on an area ranging from the Vistula and upper Dniester Rivers to the Baltic coast, and the Černjachov culture, which stretched from the area around the Bug, Don, Dnieper, and Dniester Rivers to the Black Sea and banks of the Danube.21 Archaeological evidence suggests the earlier Wielbark culture was filling in the area left behind by the Przeworsk groups in the areas of the upper Vistula and Oder, and lower Bug Rivers. Wielbark cultural expansion eventually came to include the Goths, Heruli, Gepids, Taifali, and probably the Rugi.22

The territories between the Nogat and Warta Rivers spreading southwest across the Vistula into Masovia were occupied by the Przeworsk culture during the first and mid-second centuries AD. This culture is typically associated with the Vandals by regional archaeologists. By circa 150 the Przeworsk culture had moved out of this area and was attacking areas in Dacia, with the 'Vandals' moving into the territory formerly held by the Costoboci23

The Černjachov culture appears at the end of the second and beginning of the third centuries with an increase in settlement density during the third and fourth centuries. Černjachov sites reveal a high amount of cereal production such as wheat, barley, millet, rye, and oats, with iron coulters and ploughshares regularly utilized. Animal remains from these sites primarily include ox, with sheep/goat, pigs, and horses appearing to a lesser extent. Černjachov industries included wheel-thrown pottery with village-distinctive patterns, as well as bronze, iron, and silver smithing. Some of their work was of quite

21 It appears that the Wielbark culture appeared earlier than the Černjachov culture and had an increase in settlement density during the first and second centuries.
intricate detail, such as the silver brooches found at the fourth-century site of Pietroasa. Černjachov glass production in the fourth century was exported throughout central Europe via the river systems.²⁴

The archaeological record supports the rather scant historical references that place the ‘Goths’ in the general area of the Wielbark culture during the first and second centuries and in the Černjachov cultural area during the third and fourth centuries. Jor danes’ account of the Goths migrating from the mainland opposite Scandinavia to the area around the Black Sea can thus be generally tenable. Many of the diagnostic features of Wielbark culture are seen within the elements of the Černjachov culture,²⁵ suggesting both adoption and assimilation. Hence the nascent Gothic groups were familiar and adept at a wide range of craft and technical industries including metalworking and the use of river craft for trading.

Prior to their incursions in the fourth century at least some Gothic groups gained experience in the utilization of ship and boat technology. The Goths typically lived in settled agrarian communities, although the Black Sea was easily accessible as were large navigable rivers that wound through their settlement areas.²⁶ Raiding by the Gothic cultures began around 238 through the corridors south of the Carpathians and over the Danube, and between 254 and 276 the Goths were settled on the northern shores of the Black Sea where they used local ships and sailors to raid cities on the Anatolian and Greek shores.²⁷ Some of these raids were ambitious, such as the attack by the Goths and Heruli in 268 that centered on besieging Byzantium. However, the raiders could not hope to take the well defended city and instead concentrated their raiding efforts via ships on the coastal areas of Thessalonica, Attica, Asia Minor, Rhodes, and Cyprus before they were finally defeated.²⁸

Connection between the proto-Gothic cultures and the Roman trade network are clear. Until the late fourth-century invasions there were at least six separate Gothic kingdoms around the Black Sea area. Large fortified sites in the region attest to their growing power, as, for example, at Basmachka, Alexandrovka, Novie Gorodok, Rumarov, Sovari, and Pietroasa. Archaeological finds from these sites include Roman coins and wine amphorae from the mid-fourth century onward. Roman amphorae represent fifteen to forty percent of total finds at typical Černjachov sites. Concentrations were higher at fortified centers such as Alexandrovka where amphorae represented circa seventy-two percent of the overall ceramic material.²⁹

²⁴ Heather, The Goths, pp. 77-84; R. Hanhoui, The Treasure from Pietroasa, Romania, pp. 78-84.
²⁵ Heather, pp. 11-25, 38.
²⁶ Priscus, Works, 25.
²⁷ T. S. Burns, A History of the Ostro-Goths, p. 28.
The Visigothic Kingdom

Visigothic origins

The conglomeration of Slavonic tribes, that became the Visigoths, were pressing on the lower Danubian frontier of the Empire and by the later 360s broke into Roman territory but were defeated. After a victory by Emperor Valens in 369, he rescinded parts of a treaty forged in 332 that included annual gifts to the Goths to ensure peaceful relations. Thereafter, the Goths were providing troops to the Romans instead.30

The Huns were the final impetus that pushed the Goths into Roman territory. Hunnic forces had moved into the Black Sea area in the mid-fourth century, which brought them into conflict with the Alans. After forming an alliance with an Alanic faction, they then attacked the Greuthungi Goths of Ermanaric. The Huns pushed this and other Gothic groups eastward and by 376 there were at least two large groups of Goths at the Danube petitioning the Empire for protection. These two groups consisted primarily of the Tervingi led by Alavivus and Fritigern, and the Greuthungi led by Alatheus and Saphrax. Valens admitted the Tervingi, and then promptly attempted an assassination of their leaders. Food supplies that were promised to these Goths were exploited by local military officials who were charging the Goths exorbitant prices. This untenable situation resulted in 378 in a major Roman defeat and death of Valens at Adrianople, where both Gothic groups in revolt had gathered.31 The victory appeared to remove the military barrier between this mixed Gothic group and the rich Roman lands to the west. However, they were not able to follow up on this victory and largely remained in the Danubian area, although the Roman defeat did promote hopes among Slavonic and Germanic tribes of further victories against Roman forces.32

Success finally came in 395, when a group of Goths under Alaric moved southward through the northern territories of Greece, in an attempt to find lands for settlement through both diplomacy and force. After raiding Greece and Macedonia in 395 and 396, Alaric negotiated a settlement for his Goths within Dacia in 397. Tribigild’s Gothic revolt in Phrygia in 399 indicated that the Empire’s problems with Gothic uprisings were far from concluded. In 401 Alaric moved his Goths into Italy where he battled Roman forces under Stilicho. After losing at Verona and Pollentia, Alaric returned to the Balkans in 403, and the next year Stilicho formed a pact with Alaric whereby Alaric’s Goths were settled in eastern Illyricum. Subsequently, the Goths led by Radagaisus arrived at the Danube in 405/406 and moved to the upper Rhine from where they crossed into Roman territory. Stilicho defeated this incursion, sending Radagaisus back towards the Danube. Here, Radagaisus’ Goths, along with the Tervingi and the

30 For example in the mid-fourth century Gothic warriors comprised a three-thousand strong contingent hired by the Empire and placed under the command of Procopius for a campaign against the Persians: Ammianus Marcellinus, The Later Roman Empire, 26.10.3.
31 This Gothic coalition was further strengthened by various groups of Huns and Alans who had joined their ranks around 377.
32 In 386 the Greuthungi led by Odotheus attempted to cross the Danube but were defeated, and some resettled in Asia Minor. Others were forced into military service: Zosimus, New History, 4.35, 38-39.
remaining Gruethungi Goths, began to coalesce, eventually, by circa 418, formed the ‘Visigoths’ of later history.

Alaric led this mixed Gothic contingent back into Italy in 407/408, where Stilicho again repelled them. Again in 409, after a slow movement through Illyricum, the Goths headed towards Italy. Finally, with the death of Stilicho, the Visigoths under Alaric and Athaulf successfully entered Italy in 410 and proceeded to lay siege to Rome, a failed attempt to gain long-term political leverage with the Eastern Emperor. Alaric died shortly after the siege of Rome and under Athaulf, the Visigoths languished in southern Italy for several years before moving to Aquitania, Athaulf having abandoned plans to lead them to Africa.

In 417/418 Theodoric I succeeded to the kingship of the Visigoths. As a new and relatively powerful political entity, the Visigoths negotiated treaties with the Eastern Emperor in 416 and 418, which established them in the Garonne valley, (within Toulouse and Bordeaux), on condition that they assist in repulsing other Germanic invaders. Here, for the first time, the Visigoths settled in a designated territory with the associated tax revenues and the resources that accompanied it. Visigothic kings began minting both gold solidi and tremisses while in Gaul, further consolidated their rapid transition into statehood.

**Visigoths in Hispania**

The Visigoth’s first military foray into Hispania was a joint venture with the Romans against the Vandals in the 420s. Shortly thereafter, the Visigoths attacked Arles in 425 and 430, and Narbonne in 436. The perceived threat from an increase in Visigothic power and their subsequent expansion drew Imperial attacks between 436 and 439; the Visigoths were subdued and later assisted the Romans against the Suevi in 446. King Euric further expanded Visigothic territory throughout southern Gaul between 471 and 476, moving forces into Hispania in 480 and quickly overrunning the entire territory save that of the Suevi in northwestern Tarraconensis. The expansion of the Franks southwards at the beginning of the sixth century effectively isolated the Visigothic Kingdom to Hispania by 508.

Visigothic government administration was largely based on the inherited Roman system. The Kingdom was divided into provinces governed by duces or comes provinciae, with these being subsequently divided into civitates. Provincial judges and numerarii were responsible for the collection of taxes. Visigoths and Hispano-Romans could legally intermarry, which encouraged the merging of

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35 The Visigoths signed a treaty with the Suevi in 446/447. After Theodoric II ascended the throne in 451, peace between the two growing Slavonic powers deteriorated, with the Visigoths successfully attacked the Suevi in 455. Wolfram, *Goths*, pp. 176-180.
populations, thereby promoting a more unified kingdom. Religious legislation detailed the duties and responsibilities of bishops and priests, who regulated the income (tithes, lands, gifts) to support the church; the church helping to maintain political power and support the nobility.

Coins continued to be minted throughout the duration of the Visigothic reign, and with the ascension of King Leovigild a new coinage was adopted that had a more national character. During the 570s the Visigoths adopted a coinage system similar to that of the Franks, and after 580 the solidus was dropped, with only the tremissis issued in the king’s name. The primary Visigothic mints were located in Toledo, Merida, Seville, and Cordova; however, a total of over eighty mints provided coinage for the Kingdom at different times. Visigothic gold coinage was debased over time just as were Roman coinage. Under King Leovigild (568-586), for example, the gold content of coinage was around seventy five percent, and remained so under Reccared (586-600), although by the mid-seventh century it had declined to fifty percent and to thirty-five percent by the beginning of the eighth century.

From 552 onward, civil war racked the Visigothic Kingdom, which culminated in the plea for Byzantine assistance in the restoration of order. Once ensconced, however, the Byzantines were reluctant to leave; Justinian considered Hispania as a portion of the original Roman Empire that would be reunited under his leadership. Despite Justinian’s ambitions, the Visigoths heavily defeated Byzantine forces in Hispania in 570 and 571, notwithstanding a continuing campaign through 577. The Byzantine presence in Hispania was consequently confined to a southern coastal strip, and eventually, in 624, they were permanently expelled. The Visigoths were able to maintain the sovereignty of their kingdom until the Arab incursions in 711.

The Ostrogothic Kingdom

The Hunnic invasion was likewise an important factor in the formation of the Ostrogothic kingdom. East of the Danube, in the northern Black Sea regions, a Gothic amalgam composed mainly of the Greuthungi Goths had expanded their territory until it abutted that of the Huns living in the steppe region. Once defeated in several skirmishes with the Huns, the Greuthungi retreated westward and the victorious Huns claimed the abandoned lands. In the fourth century many Gothic groups including the

37 Culturally, the Visigoths also adopted Hispano-Roman traits. For example, Danubian style dress was maintained in Visigothic Spain until the mid-sixth century, when a more typical Mediterranean style became predominant: Ibid., pp. 293-297.
39 These coins were the first to represent the crowned king sitting on a throne: G. Miles, The Coinage of the Visigoths of Spain: Leovigild to Aethila II, p. 21.
40 The Visigoths minted only gold coins during the seventh century with no small denominations, which resulted in an overall decrease in coinage available for transactions: Heather, The Goths, p. 286.
41 One of the largest mints, at Carthage, operated from the reigns of Justinian to Heraclius: Grierson, Catalogue of Byzantine Coins, p. 3.
42 Grierson and Blackburn, Medieval European Coinage, pp. 42-54.
43 By the third century the Greuthungi were recognized as a distinct group by Roman authors, and were to form the core of the future Ostrogoths.
Greuthungi were forced out of their lands by the Hunnic advancement toward east of the Dneister, and they settled back along the eastern Danube region adjacent to the border with Rome.\textsuperscript{44} Despite these Hunnic military victories, there is no evidence that the Huns had established over of the Gothic tribes; rather most Gothic kingdoms appear to have been independent at end of fourth/beginning of fifth century.

By the fourth century many Gothic groups attained from the Western Empire the designation of 'gens amica Romanit',\textsuperscript{45} although there are only few reports of contact with Goths by Roman writers until the mid-fourth century. Once they were near the Roman border, however, there was an increase in the socio-economic stratification in many Gothic groups due to interaction with the Roman market system and from service in the Roman military. This consolidation of wealth and prestige in individual hands prompted the growth of prominent and powerful leaders. Internal strife stemming from a failed revolt in 366 by the Gothic tribes under Procopius against the emperors Valens and Valentinian, as well as the subsequent one-sided treaty in 369, enabled the emergence of internal fights for Gothic leadership. Subsequently, Ermanaric organized several Gothic groups including the Gruethungi into a tight confederacy that would eventually comprise the Ostrogoths of the fifth century.\textsuperscript{46}

Food shortages, further Hunnic military pressures, and Roman treachery resulted in the successful Gothic uprising at Adrianople that marked the beginning of the Western Roman Empire's final struggle with the Germanic and Slavonic tribes.\textsuperscript{47} Immediate consequences of the battle included resettlement of some Goths in the Roman lands of Pannonia.\textsuperscript{48} Within the lands under marginal Hunnic influence, Pannonian Goths and Goths who were once Thracian foederati were coexisting in relatively peaceful conditions through the first half of the fifth century. However, this was short lived in lieu of a series of revolts. In 455 the main body of the Goths left the eroding Hunnic Empire and were settled by the Romans in Illyricum around the Danube as foederati, alongside Goths that had been settled there earlier. In 471 the Thracian Goths revolted, roaming throughout the Balkans in an attempt to establish more peaceful settlements,\textsuperscript{49} and two years later the Pannonian Goths rebelled moving wholesale into Thessalonica under their leader Thiudimer.

\textsuperscript{44} By the end of the fourth century the Huns, centered near the Caucasus, were attacking Persian and Roman forces in Armenia, and gradually settled in the Danube by 410/420: Heather, \textit{The Goths}, pp. 83-84, 102-103.


\textsuperscript{46} He was followed by a series of Ostrogothic and non-Gothic dukes that kept the confederacy together through successful campaigning and economic prosperity.


\textsuperscript{48} A large number joined the Hunnic Alliance. Other Goths fighting on the side of the Huns were at battle again with the Romans at the Battle of the Catalaunian Fields in 451: Wolfram, \textit{Goths}, pp. 177-178.

Leo (457-474) was forced to send troops against these various Gothic revolts. His victory over the Pannonian Goths resulted in their resettlement in Eordaia, Macedonia. More problematical for the Emperor were the Thracian Goths who, persistent in their rebellion despite military actions, attacked and looted large cities. Eventually, Leo made a treaty with the Thracian Goths and hoped to play the two tribes off one against another in the future. In 478 the Thracian and Pannonian Goths made a pact after one such Imperial attempt to foment a fight between them, which resulted in a united Gothic front in the face of Imperial opposition. The Pannonian Goths subsequently marched on Constantinople to extract concessions, and forced the Zeno (474-491) to negotiate treaties with the Thracian Goths that year and the Pannonian Goths the next.

The peace was short lived, and Zeno attacked the Pannonian Goths in 479 and the Thracian Goths in 480. Retaliation came when the Thracian Goths attacked Constantinople in 481 and the Pannonian Goths ravaged the southwestern Balkans for most of 482. Zeno had now killed all the Gothic leaders, except Theodoric. The latter was to unite under his command these disparate Gothic groups, who came to be known as the Ostrogoths. Zeno again sued for peace and in 483 ceded lands in Dacia and Moesia to the Ostrogoths along with payments of gold and the office of magister militum praesentalis for Theodoric. Within two years the Ostrogoths again revolted until another treaty was drawn between Zeno and Theodoric in 487. The following year Theodoric led the Ostrogoths towards an apparently weak Italy in an invasion effort that was part of an agreement with the Eastern Emperor Zeno. After defeating the Gepids in crossing the Danube, the Ostrogoths met and defeated Odoacer twice in Italy in 489. With Odoacer holed up in Ravenna, Theodoric implemented a sea-blockade in 492 and was victorious by 493. Theodoric now effectively controlled Italy and in an attempt to establish his legitimate rule struck an agreement with Anastasius, Zeno’s successor, in 497.\(^5^0\)

The *hospitalitas* system, whereby Ostrogothic troops and lords were integrated into the Roman landholding structure, proved successful for the Ostrogoths in Italy by facilitating the transition of Roman territory into the various kingdoms.\(^5^1\) Theodoric instituted a program of new construction and restorations, including the repair of aqueducts, building of public baths, new city walls, and construction of palaces in Rome, Ravenna, Verona, and Pavia.\(^5^2\) Theodoric embraced many Roman ways in the rule of Italy, including that of law and support of the Papacy. The adaptation of the Roman bureaucracy already in place allowed him to more easily collect tax revenues. With these tax revenues, he made efforts to create


\(^5^1\) Burns, *Ostro-Goths*, pp. 13-14. At its most basic and technical level, the *hospitalitas* system dealt with the rules of billeting troops whereby each soldier was entitled to one-third of the estate. In Italy it appears that one-third of Italian lands were liable for Ostrogothic settlement, and rents were paid by Roman owners of undivided estates equating to a one-third portion: Jones, *Later Roman Empire*, pp. 249-251.

a modern kingdom; for example, he sponsored a 'classical' education for the youth. The Ostrogoths minted gold *solidi* until circa 540, while silver coinage was minted predominately in Ravenna throughout Ostrogothic history. Theodoric greatly increased and expanded Ostrogothic power during his kingship through obtaining control of the Visigothic kingdom by circa 511. After Theodoric's death the kingdom's power declined and it experienced a series of mostly ineffectual and weak kings, save for Totila.

During Totila's reign the Ostrogoths were faced with Justinian's reconquest efforts and were under attack by 536. After the initial Roman success general Belisarius was recalled to the East. This allowed Totila to push the Roman forces southward beyond Naples by 543 and entered Rome in 546. Belisarius returned to retake Rome in 547, but was recalled to Constantinople a year later thereby allowing Totila to take Rome in 549. Totila was eventually defeated and killed at Busta Gallorum in 552 and Teias was proclaimed king. Teias immediately reorganized the Ostrogothic and Frankish treaty, and then attacked the Roman forces in southern Italy. With his desperate campaign failing, the Franks entered Italy in 553 but could not save the Ostrogothic forces; the last major Ostrogothic forces were crushed in 555. A final revolt by a small number of surviving Ostrogothic forces in northern Italy was defeated in 561, and with them the Ostrogothic Kingdom faded into history.

Procopius maintained that the Ostrogoths had little experience with ship technology before arriving in Italy, but he was not well versed on their origins, early cultural material, or activities. It would be more reasonable to assume that the Ostrogoths had a less developed water transportation technology within their culture than did the Romans, and that it was primarily centered on river transportation. However, they were quick to adopt sea transportation technologies in both commercial and military activities.

**The Vandalic Kingdom**

**Vandal origins**

The Visigothic incursions represented only a portion of the infiltrations into the Roman domain during the early fifth century. In 406 a large contingent of Germanic peoples, including the Suevi (a

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54 The chief Ostrogothic mints were located in Rome, Ravenna, and later in Pavia. *Nummi* were primarily minted in Rome under senatorial authority during the early part of the Kingdom. The Naples mint opened in 661/2 well after the Ostrogoths had been defeated: Grierson and Blackburn, *Medieval European Coinage*, pp. 32-38; Grierson, *Catalogue of Byzantine Coins*, p. 48.
55 In doing so he moved their treasury to Ravenna, took control of the tax system in Hispania, and stationed his troops and officials throughout Visigothic territory: Heather, *The Goths*, pp. 226-228.
Marcomanni and Quadi amalgamation), the Vandals (Saling and Alsding), and the Alans broke through Roman borders.58 Beginning their westward drive into Gaul, the Vandals, with contingents from the Alani and Suevi, crushed Frankish and Roman resistance.59 The Franks, federates of the Western Empire, managed to induce the Vandals further west and out of their territory in Gaul. This Vandal coalition pushed through southern Gaul and drove directly for the Pyrenees, but were turned away by a private Roman garrison in 409. Persistence afforded them entrance into Spain by 410 where they embarked on a period of pillaging.60 Once in Hispania the Asding Vandals and some Suevi settled in Galicia, while the Silingian Vandals settled in Baetica. The Suevi, long-time enemies of the Vandals, preceded to set up their own kingdom in extreme northwest Iberia. Gunderia was the first known Vandal king, and ruled for eighteen years.61

During the Vandal tenure in Hispania the term “Vandal” came to include a large contingent of different tribal peoples under the rule of a single king. The majority of the peoples were from the Asding and Silingian Vandal groups. However, this Vandal kingdom was quite heterogeneous and included peoples from the Alans, Hispano-Romans, Goths, and Suevi. This amalgam had some stability as the groups eventually traveled as a unit to North Africa.62 Settled on the southern coast of Hispania, the Vandals began their familiarization with the use of ship technology initially by pillaging the Balearic Islands, where they sacked the cities of Carthago Spartaria and Hispalis, and subdued much of the islands in 428. Under King Gunderia the Vandals incorporated the Balearic Islands into their sphere of political control.63 During these operations the Vandals required the transportation of land forces across the sea in addition to a minimum amount of defensive and offensive naval capabilities. Such ventures would be a precursor for later Vandal use of sea transportation in military campaigns.

For reasons unclear, the Vandals left Hispania and sought their fortunes in North Africa. King Gaiseric first attacked a large band of Suevi to cover his rear, and then began the invasion of Mauritania in May of 425.64 Clover asserts that tens of thousands of Vandals crossed from Hispania to Africa

58 The Alans were a tribal group from the steppes north of the Black Sea that had been pushed westward by the Huns: Bury, *Invasion of Europe*, pp. 51, 55.
59 Following the invasions of 406, the Burgundians entered eastern Gaul in 407. Unlike the Franks, however, the Burgundians were not invited into Roman territory as *foederati*, and they now had to be dealt with by the Empire through either giving them this designation or with military force: Ibid., pp. 102-103; Wallace-Hadrill, *Barbarian West*, pp. 24-28.
61 Ibid., 72-73.
62 Goths were reported to be included with the Vandals on the migration to N. Africa: Possidius, *Life of Augustine*, 28.4.
63 Isidore, *History of the Kings*, 73. These Vandals were an amalgam of East German Goths, West German Suevi, Hispano-Romans, and Iranian Alans: J. H. Humphrey, “Carthage and the Vandals,” in *The Late Roman West and the Vandals*, ed. F. M. Clover, p. 3.
64 Isidore, *History of the Kings*, 74; Hydatius, *Chronicles*, 77-80.
(Mauretania Tingitana), although it is uncertain how many actually crossed in the initial invasion or later.\textsuperscript{65} It would seem logical that Gaiseric's motive for attacking the Suevi in an area they were abandoning was to ensure the safety of a less defended body of Vandals while a more militarized contingent forayed into Africa. Hence the migration may have lasted many weeks or months, a length of time that would have made the remaining non-military contingents vulnerable. It wasn't until 430 that the Vandals seized Hippo Regius located some four to five hundred kilometers from their landing area. Although a treaty in 434 with the Theodosius II (408-450) briefly brought peace, the Vandals invaded Carthage by 439.\textsuperscript{66} Shortly after the conquest of Carthage, King Gaiseric entered into treaties with Valentinian III (425-455) in 442 and Zeno (474-491) in 474, which resulted in the designation of the Vandals as federates.\textsuperscript{67}

As the Vandals possessed at least minimal naval capabilities, the question arises about why their progression eastward across North Africa to Carthage was prolonged to the extent that it was. The passage to North Africa from Hispania signaled a further expansion of sea transportation in Vandal operations and of technological and cultural maritime knowledge already acquired for their use of ships to attack the Balearic Islands, and yet they did not proceed immediately to the obvious prize of Carthage, postponing the conquest of the surrounding lands until later. Furthermore, the slow progression by land allowed Carthage and other large cities a longer period to prepare for their defense. A combination of factors probably prevented a straight out assault on Carthage. The vast majority of the Vandals' ships were likely merchant vessels built, bought, or commandeered for the crossing. Although adequate for ferrying their land forces, the Vandal fleet could not adequately face a significant naval presence in southern Hispania at that time.\textsuperscript{68} The \textit{classis Africana} assuredly contained enough warships to deter a direct landing near Carthage. The Empire had attempted to deny the Vandals access to ship technology for such a venture, although once in Carthage the Vandals gained access to and fully used a well-developed knowledge base in ship technology for their trade and military activities.

\textbf{Vandal North Africa}

In the West, grain and other foodstuffs were especially still required from North Africa. With Carthage under their control, the Vandals set about to solidify their new kingdom. From the Vandal perspective treaties with the Empire offered several things: access to needed trade markets that ensured a thriving economy, legitimacy for the ruling aristocracy in the eyes of the Roman and other competing

\textsuperscript{65} Debates over the number of individuals crossing with King Gaiseric range from a few to many thousands. Utilizing a supply of merchant ships, which were similarly used for attacking the Balearic Islands, the Vandals could have easily transported large numbers of individuals in a short period of time.

\textsuperscript{66} "Carthaginiae magna fraude decepta die XIII kl. Novembris omnem Africam lex Gaisericus inaudit," Hydatius, Chronicles, 107.304.15; also see Clover, The Late Roman West, p. 13.

\textsuperscript{67} Such treaties were only an afterthought formalized and the best outcome that the Emperors could achieve from the situation. From the Eastern Roman Imperial perspective, they hoped to ameliorate raiding and future conflicts: Humphrey, "Carthage and the Vandals," p. 2.

\textsuperscript{68} Through competition which the Vandals may have otherwise developed a naval power significant enough to have immediately attacked Carthage.
Slavonic and Germanic powers, and increased links involving prestige exchange. Fortunately, the only immediate military threat arose from the native Mauri pastoralist tribes who battled the Vandals from 480 to 533, with only intermittent threats from the Ostrogoths and Romans.

Political and economic power in Vandalic society rested with the nobles, the Arian ecclesiastical hierarchy, and warriors. Throughout their rule in North Africa the royal clan of the Hasdingi produced all six of the kingdom's monarchs. Each of these kings claimed the title *Rex Wandalorum et Alancrum*, literally "King of the Vandals and the Alans". From the available evidence the Vandal kings appear to have been independent of Roman authority, and in modern terms could be characterized as despotism. The North African economy was in a slight decline prior to the arrival of the Vandals, although Carthage remained one of the wealthier port cities in the Mediterranean. Pre-Vandalic North Africa was providing the *annona* to the remnants of the Western Roman Empire in Italy, as well as conducting trade in fine and coarse wares throughout the Mediterranean and Europe. Archaeological evidence indicates that under the Vandals, North Africa continued to be a significant participant in inter-regional trade.

In establishing their power in North Africa, the Vandal's treatment of the indigenous Roman population varied. Procopius states that the Vandal nobility confiscated some estates, while the others were only heavily taxed. Archaeological evidence corroborates some Roman continuity since wealthy Romans were living in townhouses and villas during Vandal occupation, and it appears that during the late fourth/fifth century members of *collegia* were leaving towns for the countryside and villa patronage. Evidence from law codes, inscriptions, and other records also indicate the survival of Roman aristocracy under Vandal rule; the Albertini Tablets, for example, indicate that Roman aristocrats remained landowners. Vandal rulers also helped their populations by setting up tax-free land allotments for warriors in Carthage, Byzacium, and E. Numidia. Tax revenues supported the upkeep of and construction in the larger cities, especially Carthage, and many curialile positions were replaced by the Vandal aristocracy who now funded new building and refurbishment projects. The *Curiae*, comprised of aristocrats along with former Roman office holders, in the towns of Vandal Africa were responsible for governing and were present up to King Huneric.

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69 Humphrey, "Carthage and the Vandals," p. 3.
71 P. Reynolds, Trade in the Western Mediterranean, A.D. 400-700: The ceramic evidence, p. 112.
72 Procopius, History of the Wars, 3.5.12-17.
74 S. J. Keay, Late Roman Amphorae in the Western Mediterranean: A Typology and Economic Study, p. 192. These lands were often former large estates held by Senators in North Africa during the third and fourth centuries as part of many estates around the Empire: Clover, The Late Roman West, p. 6.
75 C. Courtois, Tablettes Albertini: Actes privés de l'époque vandale (fin du Vème siècle), pp. 4-27.
Carthage itself appears to have been well attended to during Vandal rule. From archaeological remains, contemporary historical accounts, and period literature it is apparent that Vandal kings maintained functioning streets, markets, baths, palaces, fori, houses, circi, amphitheaters, plazas, schools, and churches. Some structures were destroyed during the initial siege, but most civic structures were not destroyed and many that were damaged underwent repairs and refurbishments. Palaces, circuses, amphitheaters, and schools were all actively used under Vandal rule throughout the fifth and sixth centuries. Carthage had a very active entertainment culture, especially the amphitheater shows, races, and plays. New walls were built at Carthage between 420 and 430 and maintained thereafter. Most importantly Carthage's port facilities were maintained. Located to the south in the present-day Bay of Daram, this network of harbors included a main rectangular harbor and an inner circular one.\textsuperscript{77}

The Vandals also issued coinage that provided an economic stimulus and legitimacy to their new government. Carthage was an important Imperial mint up to the reign of Constantine, and again at the end of fourth century before the Vandal conquest.\textsuperscript{78} Vandal kings issued gold coinage beginning with King Gunthamund (484-496). They used their own images on these coins, a further indication of independence from Roman authority.\textsuperscript{79} Gunthamund, Thrasamund, Hilderic, Geilamir also issued silver and bronze coins in their name, and large bronze coins issued in the city's name.\textsuperscript{80}

Vandal relations with other kingdoms and the Empire were mixed. Marriage alliances were formed between the Vandals and Ostrogoths in 500, when Vandal King Thrasamund wed Theodoric's sister Amalafrida. Conditional with this arrangement 5,000 Gothic troops were sent to Carthage. Heather interprets the presence of troops as some form of hegemony over the Vandals by the Ostrogoths,\textsuperscript{81} however such a characterization does not fit the overall evidence of a sovereign Vandal North Africa that circulated its own currency and independently conducted its international affairs. Eventually King Hilderic (523-530) killed the Ostrogothic troops in 523, ending any pretense for the Vandals having been a vassal state. Relations with the indigenous Mauri of North Africa were favorable for most of the fifth century, turning sour between 480 and 533 during which time the Mauri began attacks on the Vandals.\textsuperscript{82}

\textsuperscript{77} Ibid., pp. 5-15. Although not as many animal shows were produced in Carthage.

\textsuperscript{78} Ibid., p. 9.

\textsuperscript{79} F. M. Clover, "L'Annee de Carthage et Les Debuts du Monnayage Vandale, XI," in Histoire et archeologie de l'Afrique du Nord, pp. 215-218. Some earlier scholars have claimed that there was no Vandal gold coinage, but only copper nummi and silver denarius: see Grierson and Blackburn, Medieval European Coinage, p. 19. However, it is unlikely that one of the wealthiest of all the Slavonic and Germanic kingdoms issuing gold coins would not have issued their own.

\textsuperscript{80} W. Wroth, Catalogue of the Coins of the Vandals, Ostrogoths, and Lombards and of the Empires of Thessalonica, Nicaea, and Trebizond in the British Museum, pp. 3-16. After the reconquest of Africa by the Romans and later by the Arabs, the mints in Carthage continued to operate from 533-695: Grierson, 1968, Catalogue of Byzantine Coins, p. 43.

\textsuperscript{81} Heather, The Goth, p. 491.

\textsuperscript{82} These attacks served to occupy Vandal military resources and thus benefited the Eastern Roman Empire's attempts at reconquering North Africa: Humphrey, "Carthage and the Vandals," p. 2.
After a century of prosperity and consolidation of power, the Vandal kingdom was overwhelmed by the superior forces brought to bear on them by Emperor Justinian in 533.

**The Early Frankish Kingdom**

From the late third century onwards, Roman leadership was preoccupied with the ever-increasing forays by Germanic tribes into the northern and eastern European territories west of the Rhine and Danube rivers. One of the most successful and lasting Germanic kingdoms formed out of Imperial lands was that of the Franks. The first mention of the Franks as a confederacy was around the end of the third century. James lists several groups entering this confederacy at different times, including the Chamvi in 289, Bructeri in 307, Chattuari from 306 to 315, Saliens in 357, and the Amsivarii and Tubantes from 364 to 375. The Franks, along with Alamanni, were pushing over the lower Rhine in the 250s and raiding in northern Gaul during the 270s. Frankish raids were not limited to land, as they were conducting operations along the coasts of Britain from the 260s through the mid-fourth century. Moreover, the Germanic groups that eventually comprised the Franks, the Bructeri and Usipi, Chamavi, Salian Franks, and some Saxons, each had a history of maritime activities extending back to at least the first century BCE. After decades of raiding Roman territory, the Franks were allowed to move into and settle the lands of Belgica, just west of the lower Rhine. Designated as *foederati* by the Empire in 358, they were charged with protecting a portion of the border in exchange for their land and the right to exploit its agricultural and tax resources. Even before Roman acquiescence, significant Frankish communities were forming in northern Gaul by the fourth century. Excavated material from later burial sites indicate the probable presence of both soldiers from previously unsettled tribes and *foederati* settling on former Roman territory.

There appears to have been relatively peaceful relations between the Franks and the Empire from around 320 until 350, when another wave of invasions occurred that included some Franks. In 357/358 the Emperor Julian campaigned against the Franks and settled the defeated group at the mouth of the Rhine (Toxandria). These *Sali*, or “Salian” Franks as they became known, had peaceful relations with the Empire until the mid-fifth century when the Huns were hired by the Empire in the 430s to again check the Franks and the Burgundians. Many of the tribes associated with the Frankish confederacy continued to battle with the Empire, notably during the reign of Julian, but were summarily defeated.

The Frankish King Clovis, traditional founder of the Merovingian kingdom, was campaigning around the end of the fifth to the beginning of the sixth century in northern Gaul. In 496 Clovis began pushing southward to Saintes, taking the city of Bordeaux by 498, and his forces had taken over the bulk of the Alamannic kingdom between 496 and 506. Although a treaty was struck with the Visigoths in 500,

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83 E. James, *The Franks*, p. 35.
84 Ibid., pp. 44-48.
the Franks were attacking deep into Narbonensis, reaching Arles by 507 and by 508, they were in control of most of Aquitania. In 507 Clovis attacked the Burgundians, greatly expanding Frankish controlled territory and also incorporated the upper Rhineland Franks into his kingdom. By Clovis’ death in 511, all other smaller Frankish groups were assimilated into the Frankish kingdom.  

Upon Clovis’ death the kingdom was divided between his four sons, a pattern that hindered the Merovingian kingdom throughout its existence. Throughout the 530s and 540s there were numerous disputes with the Visigoths in Aquitania. Additional conflicts arose when the Franks attacked the Thuringian Kingdom from 531 to 534 and conquered the Burgundians between 532 and 533. By 536 the Franks controlled all of Gaul except for Brittany and Septimania, which remained under Visigothic rule. Their effective eastern boundary was at the Rhine, although they occupied both sides of the lower Rhine. The Alamanni straddled both sides of the upper Rhine, the boundary between the Franks and Alamanni running along the Mainz and Worms rivers. By the end of the sixth century the remainder of Gaul was wrested from Visigothic and Ostrogothic control through a combination of force and diplomacy. Provence, for instance, was gained through a deal with Witigis in exchange for military aide against Justinian, which in turn give the Franks access to Arles and Marseilles.

A fundamental problem encountered by the Merovingian kingdom was the subdivision of its territory between the sons of a king after the king’s death, and the subsequent warring between these smaller kingdoms. For example, Merovingian Gaul was partitioned into four separate parts after the death of Chlothar I in 561, which set in motion continued squabbling over territory throughout the remainder of the Merovingian period. King Dagobert (622-638) is considered to be the last of the great Merovingian kings; he was followed by a series of weak leaders ruling over divided lands, a situation that led to the foundation of the Carolingian dynasty in the seventh century. During the sixth century, the Franks and Gallo-Romans in northern Gaul became blurred as each had adopted aspects of the other’s culture, the amalgam being referred to as the ‘Franks’. There was less integration by the sixth century in the south of Gaul, where the settled Franks referred to the indigenous people as Romani and themselves as Aquitani. All peoples living in Gaul, however, were considered ‘Franks’ by outside governments and writers in the period.

As with the other Germanic and Scythian kingdoms, the Franks were engaged in the minting of their own coinage. Between 500 and 587 the Franks issued good quality imperial soli and tremisses, but after a time these coins began to loose some of their weight. Merovingian Frank copper coinage was also issued for smaller transactions. Sometime in the 580s lighter soli and tremisses were introduced in addition to the older and heavier coins. Frankish coins maintained their demand as a means of storing

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87 Ibid., pp. 79-91.  
88 James, The Goths, pp. 95-96, 104.  
89 Ibid., pp. 8-9.  
90 Grierson and Blackburn, Medieval European Coinage, pp. 90-102.
wealth, reflecting the kingdom's ability to maintain substantial political and economic strength during Late Antiquity. Frankish monies were sought outside the kingdom, in both the Mediterranean and northern Europe. For example, Merovingian coin hoards have been found in England at Canterbury dating to circa 580, at Faversham dating to circa 590, and at Crondall dating between circa 625 and 650.\footnote{Ibid., pp. 122-127.}
CHAPTER IV
FEATURES AND TRENDS OF SHIP CONSTRUCTION

Introduction

Having outlined general historical trends in Chapter III, I will in this chapter provide a descriptive analysis for a large part of the archaeological and iconographic evidence for ship technology in the second through seventh centuries. The first section of this chapter is devoted to a purely descriptive outline of the structural elements of the vessels used in this study, as well as outlining the basic sizes and shapes of these vessels. In order to identify trends in the attributes of individual ship elements over the period of study, and differentiate these elements between Mediterranean and European construction traditions, elements are individually described in the first section of the chapter. For example, all central longitudinal timbers will be described together, whether they be keels or keel planks. The associations of elements with various building traditions, and the subsequent relationship of these traditions with one another, are discussed in the conclusions of this chapter. Where there are an adequate number of archaeological examples, I compare timber dimensions and frequency of occurrences over time. This type of analysis attempts to gain some insight into trends taking place over the period of study. As outlined in Chapter II, I have combined individual elements of the iconographic examples, such as number of masts or individual decorative motifs, into charts in order to show the frequency of occurrence for these elements. In discussions in this chapter that refer to the iconographic evidence, I cite the chart pertinent to the discussion. I do not analyze individual iconographic examples unless explicitly noted. For the individual depictions and their references, the reader should refer to the Appendices at the end of the work. In the conclusions of the present chapter, I outline the basic trends and developments associated with ship and boat technology for the period studied. The two chapters following this one serve to place these trends in their historical contexts and demonstrate how water transportation technology was applied. In Chapter VII, I conclude by offering several hypotheses as to why the trends took place.

Below, the shapes and sizes of vessels, their separate timber elements, different fastening methods, and other functional and decorative elements used in a vessel’s construction are all discussed. The design and relationship of each of these characteristics are important to the performance of a vessel for its required duties. It is the consideration of a vessel’s function matched with the skill of and materials available to a shipwright that result in a particular vessel design.

In constructing a ship’s hull, the shipwright must reach a compromise between rigidity-strength and flexibility. Each must be considered in order to prevent the hull’s collapse when subjected to stresses. A hull must be strong enough to withstand tensile and shearing forces, but must also be flexible enough to allow the absorption and distribution of forces without having to overbuild the vessel. Of the longitudinal stresses acting on a hull, particularly of seagoing vessels, the primary are those caused by hogging and
sagging. These stresses mostly result from changing buoyancy along the hull’s length, causing a differential in the hull weight at its ends versus at midships. Longer vessels will have a greater susceptibility to these stresses than smaller ones, especially in relation to wave action that exacerbates the differences in relative buoyancy. Hogging and sagging stresses are countered by providing adequate longitudinal stiffness in the hull.\(^1\) Ships also have a tendency to flex laterally, forcing the sides of the hull towards and away from one another. Hence attention must be give to appropriately robust transverse support in order to prevent the hull from being worked apart.

Design considerations during construction also directly affect a ship’s inherent stability. A ship’s stability is a function of its hull shape and weight distribution throughout the hull. Ideally, to increase stability, weight is distributed lower in the hull rather than higher. Furthermore, the lower the draft-beam coefficient, the greater the degree of inherent stability is in the hull. A ship’s stability can be technically calculated by determining the location of its metacentric height (MH) within the hull.\(^2\) The calculation of MH is determined from the distribution of weight within the hull, both horizontally and vertically, and the center of gravity in relation to the plane around which the ship rolls, or metacenter. Technically, the metacenter is the intersection of planes passing through the center of gravity and buoyancy; provided the center of gravity does not shift, this intersection remains the same for all roll angles. Ideally most of a vessel’s weight, or center of gravity, should be located below the buoyancy plane. If it is far below it, resulting in a high MH, the vessel would right itself quickly and be considered stiff. Such a ship is quite stable, but may provide a relatively rough ride for both passengers, cargo, and rigging. If the center of mass and the metacenter are close, resulting in a lower MH, the vessel is considered tender. Although such a ship would provide a smoother ride, it has an increased risk of becoming unstable and possibly capsizing.

There are generally two methods utilized to increase the stability of a hull. The center of gravity can be lowered in the hull, typically by placing ballast low in the hold, filling the hold with a heavy cargo, loading the heavier below the lighter cargo, and/or by placing heavy timbers lower in the hull. Additionally, the ship’s center of buoyancy can be changed in relation to its metacenter by altering the design of the ship, and creating a higher MH.\(^3\) One manner of changing the ship’s center of buoyancy can be achieved by designing the vessel with a greater beam in relation to its draft, or by increasing its beam-draft coefficient.\(^4\) Hence, wider ships sitting lower in the water, with their weight distributed in the lowest portions of the hull, achieve the greatest degrees of stability.

\(^1\) Rockered keels also address these stresses although apparently this was not a solution utilized during Late Antiquity.

\(^2\) Metacentric Height (MH) = Distance between center of mass (G) and the meta center (M).

\(^3\) This results in increasing the distance between the metacenter and the center of gravity.

\(^4\) The beam is independent of the ship’s length in relation to increasing the center of buoyancy. S. McGrail. *Ancient Boats in North-West Europe, the Archaeology of Water Transport to AD 1500*, pp. 13-16.
The relationship of a ship's length to beam has more bearing on the ship's ability to maximize speed than on its stability. In determining a vessel's length-to-beam coefficient, a shipwright has to consider several different factors including the ship's operational area, types of cargo to be transported, and method of propulsion. There is no ideal length-to-beam coefficient, although, in general, the coefficient is positively correlated with the greater rate of speed attainable given the same amount of propulsive force and displacement. Such considerations were most important for vessels powered at times by oar, such as warships. However, the trade-offs associated with higher length-to-beam coefficients are a reduction in hold capacity given the same area of hull, and a reduction in the vessel's stability. Thus, where speed is an important consideration for a vessel's function, such as in military vessels, the design will typically have a higher length-to-beam coefficient. Vessels built with greater considerations for maximizing the amount of cargo capacity than speed, such as merchantmen, were typically designed with lower length-to-beam coefficients.

Size and Shape of Vessels

Overview of size

For the period under consideration only eighteen shipwreck sites, the majority of which date to the third and fourth centuries, have yielded sufficiently preserved watercraft remains to allow for overall estimations of vessel length. A pattern emerges when these vessels are grouped by increments of five meters in overall length (Chart 1). A great majority of the ships into the third century had been over twenty meters and half over twenty-five meters in length. This is in direct contrast to the fourth century where all but one vessel had been under twenty meters and over half under fifteen meters in length. For both the fifth and seventh centuries, there were only two vessels available for which we have good length estimates, and in either case one of these had been over twenty meters in length, and one under. The single vessel from the sixth century had been under fifteen meters in length. Additional examples are needed from the fifth through seventh centuries to demonstrate more clearly what appears to be a trend towards downsizing of vessels during and after the third and fourth centuries (Chart 2).

Literary evidence also provides some indication of vessel size. Sometime during the second century a vessel sailed from Alexandria to Rome reportedly carried two hundred and seventy-six individuals on board. Many large ships traveled this prominent trade route, most notably the large grain carriers bringing their produce to Rome. Such a reference is admittedly vague and does not provide much specific information about the ship in question. However, some speculation can be made based on the

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5 One of these, the vessel from Pantano Longarini, will be omitted, since its reconstruction and identification as to vessel type are quite problematic. Personal communication from Frederick H. van Doominck, Jr., April, 2001.
6 There were only a few ships available dating to the later three centuries where good length estimates were available. Hence the observations are more tentative.
7 Acts 27.37. Although it is possible to imagine a second deck of some configuration that held passengers, there is no archaeological evidence for multi-decked vessels for passenger stowage in Late Antiquity.
number of passengers mentioned. A vessel of thirty-six meters in length and with a twelve-meter beam, consistent with the archaeological examples of the second century, would have had approximately 260 to 280 square meters of deck space depending on the vessel’s particular plan shape. This would provide roughly a square meter for each person on board; somewhat crowded for the crew even with people huddled together. Increasing this vessel’s size to forty by fourteen meters would enlarge the deck space to around three hundred and forty to three hundred and sixty five square meters, providing a more workable space allotment. Such a large vessel would certainly have been at the extreme upper range of vessel sizes, and it is possible that the reason for mentioning this vessel was due to its unusually large size. It is possible that individuals were also kept below deck and crowded together to a greater degree. However, this would indicate a somewhat unusual instance of a ship contracted solely for transporting individuals, as large ships running the Alexandria to Rome route at this time were typically transporting grain and other foodstuffs. If the vessel did carry passengers below deck, it would not have been of a size outside those represented in the archaeological data set from the second century. A more concrete reference to vessel size from the end of the second century by Scaevola tells us that the two tonnage sizes of fully laden grain carriers utilized during the early Imperial period were ten thousand and fifty thousand modii, or around sixty-five and three hundred and twenty-five tons respectively.\(^8\)

Another, more vague, reference dates to the mid-fourth century, when Ammianus Marcellinus mentions a ship used in the overseas transport of an obelisk from Egypt to Rome for use on the spina in the Circus Maximus.\(^9\) This obelisk was erected in 357 and was 106 feet, or just under 32.5 m, in total height.\(^10\) He records its shipment from Alexandria to Portus took place on a specially constructed ship of “unheard-of size” that required three hundred rowers. It is certainly possible that this vessel was rowed because the obelisk had to be placed along the ship’s centerline to maintain stability, thus leaving no room for a conventional mast(s). Considering the obelisk’s length, a vessel of at least 40 meters would have been required to carry it, although the ship certainly may have been a bit larger, if the obelisk were placed into the hold. Such a vessel would have been at the upper limit the size range based on archaeological evidence (Chart 1), and its unusually large size would have been the product of an atypical venture funded by the state. If the large obelisk had been placed in the hold, it would have alleviated problems of ship stability. The difficulties of loading the obelisk into a hold would have been great, but not unlike those met when the obelisk was unloaded onto a sled and dragged three miles to Rome, or pulled to an upright position in the Circus Maximus, as it could have been inserted before the ship’s construction was completed.\(^11\) It is also possible that the obelisk was stowed on deck. Although the problems of lading

\(^{8}\) Scaevola, Digest, 50.5.3.
\(^{9}\) Ammianus Marcellinus, The Later Roman Empire, 17.4.12-15.
\(^{10}\) P. MacKendrick, The Mute Stones Speak, p. 417.
\(^{11}\) Ammianus Marcellinus, The Later Roman Empire, 17.4.12-15. This operation entailed the building of a specially designed vessel.
were reduced, additional problems of stability arose. These may have been overcome by loading a heavy cargo in the hold. However, the combination of the obelisk and a cargo in the hold to offset the obelisk placing a great weight high in the vessel would have resulted in a vessel with an extraordinary tonnage capacity. Regardless of the manner that the obelisk was stowed, the passage indicates that the ship required to ferry the obelisk would have been quite large, probably around forty meters in length. Ammianus' mention of the conspicuously large size of the vessel supports the contention that vessels of such large size were rare by the late Imperial period. The typical vessel sizes must have been much smaller, around 20 – 25 meters in length suggested by the archaeological record.

An allusion to the sizes of what were most likely sailing vessels is found in a fifth-century account. Four hundred Heruli in seven ships attacked the territory of Lucus in 456. The references to conveying soldiers and loot suggest these ships were probably sailing vessels as opposed to oared galleys associated with raiding in the North Sea. Assuming the number of Heruli to be an estimate and that each ship was of roughly similar in size, there was an average of fifty-five to sixty troops per ship. The seven sailing vessels found in the archaeological record dating to this period are all around fifteen to twenty meters in length, and could have handled the transportation of the given troop numbers. If these were single-leveled oared galleys (the only configuration of oared galleys in the period of study as will be demonstrated below), they would have needed to be around twenty-five or more meters in length to allow for a minimum of twenty oarsmen per side, leaving an average of fifteen to twenty additional troops on board for each of the seven ships. Although it was certainly possible that these were oared galleys, these vessels would have represented larger warships for Late Antiquity, and, moreover, would have required no small modicum of training for the crews to effectively utilize the ships. As there is no evidence for these Heruli raiders having formed an organized military akin to the sixth-century states of the Mediterranean, or that they engaged in sea battles with oared warships, it may be more likely that the raiding ships were smaller sailing vessels. Due to the scarcity of detail, it is not possible to draw any firm conclusions in regards to ship size from this passage alone.

Warships used in the Mediterranean probably possessed a different overall shape than those of merchant vessels, having shallower drafts, greater overall lengths, and higher length-to-beam coefficients. As a result of these shape and dimension characteristics, they possessed an inherent lack of space and stability, and thus made poor cargo carriers. Indeed, Maurice noted the difficulty associated with loading warships with heavy gear. Due to the lack of archaeological evidence, the typical sizes and

12 Hydatius, Chronicles, p. 164.
13 Furthermore, it was unlikely that the larger powers of the Mediterranean would have allowed a minor group to train in and operate large oared warships in their waters.
14 This is a coefficient that is typically derived from dividing the length of the vessel's hull between perpendiculars by its maximum breadth: J. R. Steffy, Wooden Ship Building and the Interpretation of Shipwrecks, p. 254.
length-to-beam coefficients of Mediterranean seagoing warships is conjecture. Written accounts and shipshed evidence dating to many centuries earlier have little bearing on the problem, and an attempt to ascertain such dimensions from iconographic evidence alone is a futile and specious endeavor. In the following discussion of propulsion evidence, some very general estimates of warship lengths can be hypothesized, but such estimates cannot be corroborated until extant remains of seagoing warships of the period are discovered.

Roman warships utilized in river systems are found in the archaeological record. The two Oberstimm vessels of circa 100 found near the Danube were around 15.5 by 2.7 meters, and the fourth-century Type-A warships from Mainz were approximately 21.0 by 2.7 meters in overall size. These examples illustrate the high length-to-beam coefficients, approximately 5.7 and 7.8 respectively, typically associated with rowed vessels. Written accounts provide more general information for the size of military river craft. Julian, during his campaign in Germany in 359, ordered some three hundred men to cross the Rhine and establish a beachhead. For this operation, they were to use the forty patrol boats available, which were reportedly filled to capacity. All of these vessels were rowed, though the archaeological evidence from Mainz suggests that such boats may have had sailing capabilities as well. Assuming that all troops crossed at once, and that soldiers rowed the craft, Ammianus' figures provide an average of seven to eight men per vessel, which indicates that these were somewhat smaller boats than the Mainz Type-A river craft. The Mainz Type-A vessels held twenty-six to thirty troops each, thus it would have required only about ten such craft to move Julian's three hundred troops. Either Ammianus drastically overstated the number of troops or boats in the operation, or the craft used were actually smaller than the Mainz vessels and thus represented a different type of patrol craft altogether. It is certainly possible that smaller boats could have been pressed into service in the haste of the operation. Conversely, there may have been dedicated rowers operating the Type-A craft, resulting in enough room for only seven to eight individuals per vessel. In this case, it may have been vessels such as the Mainz Type-A river craft that were used in the operation.

Length-to-beam coefficients and shapes

Archaeological evidence is the most accurate and reliable source for an examination of length-to-beam coefficients. In the Mediterranean, the evidence is restricted to merchant vessels. It appears that length-to-beam coefficients throughout the second to seventh centuries were determined by specific

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17 Ammianus Marcellinus, The Later Roman Empire, 18.2.8-12; A. J. Parker, Ancient Shipwrecks of the Mediterranean & the Roman Provinces, pp. 291, 253-254.
19 Ibid., pp. 23-29.
environmental and economic factors and consequently had a rather wide range of values. Chart 3 plots the length-to-beam coefficients for all Mediterranean vessels with adequate data; the plots do not reveal any discernable real trend over time for the period in consideration. However, a majority of the vessels, nine out of thirteen, fall between the length-to-beam values of 2.5 and 3.0. One factor that could possibly influence these values is the overall size of the vessel, in that the largest ships may have been constructed with different length-to-beam coefficients compared to smaller boats. In order to allow for this factor, the length-to-beam coefficients were plotted against vessel length in Chart 4. Here again there is no apparent pattern, since larger vessels just as likely had a low or high length-to-beam coefficient as did smaller vessels.

Mediterranean river vessels available for length-to-beam analysis are also scarce. There are only five good examples, all of which operated on the Tiber River and the area around its mouth, with four of the vessels operating to ferry goods and supplies from Portus to Rome. These are the five Fiumicino vessels. They vary in their length-to-beam coefficient values between 3.0 and 5.0 (Chart 5). It is sufficient to note here that although these values are generally greater than those for Mediterranean seagoing vessels, they are much below those of contemporary military river craft that had only speed considerations without regards to maximizing hold space.

A greater number of river vessels survive in the archaeological record from Europe, and provide useful data for length-to-beam coefficient analysis. The length-to-beam coefficients of river craft were analyzed by grouping them into geographical regions in Chart 6, as their area of operation will typically have a smaller overall range and cross fewer cultural boundaries than their seagoing counterparts. These regions are Britain, lower Rhine or Germania Inferior, upper Rhine or Germania Superior, upper Danube or Raetia, and Italia. There are in addition the river vessels from Bevaix and Yverdon. These form a distinct category of central European craft. It is immediately evident that the vessels from Britain had significantly lower length-to-beam coefficients than those operating on the continent; the length-to-beam coefficients of the latter were more consistent with those of the Fiumicino vessels.

The river vessels from the upper Rhine represent a rather short time span, from approximately the

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20 Chart 4 includes ships built in the indigenous manner from the North Sea region; this results in a greater disparity of values.
first to the beginning of the third century. Throughout this circa one hundred to one hundred fifty-year period, there is a fairly wide range of length-to-beam coefficients in use and no obvious length-to-beam trend is observed in the region (Chart 6), although a clearer trend may be evident in the comparison of geographical regions as a whole. Moving from the lower Rhine in the north to the Danube in the south, there is a general decrease in length-to-beam coefficients. However, it must be noted that the northernmost examples are commercial transport vessels while those to the south are military craft, and this may account for the apparent geographical trend.

Archaeological material also provides some indication of the cross-sectional shape of hulls. Figure 1 illustrates nine midships sections from Mediterranean seagoing vessels in chronological order. From this limited sample, a general change from rounded hulls amidships to those with more variance in their shapes can be observed. For the period of study, the earliest vessels have a rounded midships section with fairly soft bilges and keels that only slightly project from the bottom of their hulls. It is in the fourth century that we see a combination of the “V”-shape at the center of the hull bottom, culminating in a more projecting keel, and flatter hull sections extending out from the keel. With flatter bottom sections and harder bilges, ships from this point forward were able to have designs that produced a deadrise from the keel as opposed to a continuous curve terminating at the turn of the bilge.

Bow and stern shapes also change over the period in the Mediterranean (refer to Chart 50 for iconographic evidence). From the mid-first to the mid-fifth century, seagoing merchant ships were depicted with equal frequency as having concave or convex bows, and only rarely with flat bows. Over the same period sternposts were depicted overwhelmingly with convex profiles, and only a few representations show straight sterns. Hence, the two most common bow-stern shape combinations are convex-convex followed by concave-convex. Flatter, and often rather vertical, stem and sternpost shapes become more prominent from the mid-fifth century onwards, resulting in the straight-straight shape combination becoming the second most prominently depicted during the period.

Without any archaeological examples of seagoing warships in the Mediterranean, iconographic evidence alone provides data for their shapes. During the period from circa 50 – 250, thirty-one of the thirty-seven warship depictions I have collected have a concave-convex bow-stern configuration, while only four have a convex and two a straight bow. This is significant in that scholars have traditionally equated Roman warships with concave bows fitted with rams, yet 15% of these depictions in this early period display a different bow configuration. Moreover, the following period (circa 250 – 450) have an even higher occurrence of non-concave bow shapes, with ten of twenty-three examples of warship illustrations having have straight bows and a single example a convex bow. Thus, nearly half of the examples collected from this period deviate from the ‘traditional’ concave bow shape. In most all of these depictions, ships were rendered in profile, but a first-century painting from Pompeii depicted two vessels in three-quarter view that provides additional clues to hull shape. Most clearly shown in these two
representations are the flat runs along the sides of the warships, clearly to accommodate the oars and undoubtedly made feasible by a high length-to-beam coefficient.

In contrast to Mediterranean vessels, indigenous-built craft from the North Sea region in the second and third centuries, such as the Blackfriars and Gurnsey ships,23 have rather flat bottoms without significant deadrise that result in a rather sharp turn of the bilge in the transition to their sides. A similar general shape is seen in the contemporaneous County Hall ship,24 although it was constructed with many Mediterranean characteristics. Stem and sternpost remains from the Blackfriars ship indicate long raking convex ends, and evidence indicates a similar post shape for the Gurnsey ship. These vessels had a rather 'boxy' appearance amidships. With little iconographic evidence for seagoing vessels in this period, it is difficult to determine further variations or frequencies in overall vessel shapes.

River vessels from northern Europe were typically long, narrow, shallow-drafted, and had more rectangular or box-like cross-sections along much of their length. This shape was achieved by attaching planks carved to form a hard chine on either side of a flat bottom, formed from several thick planks. Typically, a single flat plank was attached to the top of the carved chine-planks to extend the sides upwards, which resulted in a nearly ninety-degree transition from the bottom to the sides of the vessel. The ends of the vessels were not formed by posts, but with flat planks extending outwards at a steep angle.

The best illustrations of this vessel type are from Druten, Zwammerdam, and Kapel-Avazaath, although other examples include boats from Woerden, De Meern, and Kerk-Avazaath,25 Each of these vessels were found in roughly the same geographical region (the lower Rhine) and from the same general time period (of the first through third centuries).

The box-shaped river vessels used by the Roman military that have been found further up the Rhine and on the Danube have different overall shapes from the earlier rounded hulls of boats on the lower Danube and the later long box-like vessels of the lower Rhine. The best examples of the earlier vessels from the lower Danube are found in the Oberstimm vessels dated to circa 100 from near, but not in, the Danube itself. The later fourth-century vessels found at Mainz on the Rhine are the best examples of more

24 Marsden, Port of London, pp. 124-128.
box-like military craft. The Oberstimm and Mainz vessels had a stem and stern that terminated in true posts, forming a much finer entry and exit than the lower-Rhine vessels. The Mainz vessels had flat runs along their sides that forced a tight constriction at the hull extremities as the planks make their transition into the end posts. The Oberstimm vessels lacked flat runs and possessed higher length-to-beam coefficients. Thus the planks were not required to make as sharp a turn into the posts. Many, if not all, of the Mainz craft had convex stem profiles, while the Oberstimm vessel possibly had a concave stem configuration similar to some depictions of seagoing warships in the Mediterranean.

Although the Type-A Mainz vessels have been reconstructed with a concave bow shape, there is no conclusive evidence for this configuration. A single nail located at the end of the keel, used as evidence for a concave shape, could have just as easily have secured a timber for a convex stem. Considering the much more simple construction of a convex bow, the increased length-to-beam coefficient, and finer entry providing better speed, easier rowing, and that the Type-B vessels found with them did have a convex bow, it is more likely that these vessels also had a convex bow shape. The Oberstimm vessels were also reconstructed with concave bow configurations, and the evidence is unclear to doubt this reconstruction at the present time. Although others have argued that the Oberstimm vessels did have convex bows, and they well may have, these are equally only hypotheses without evidence to substantiate them to date.

All these river warships had a convex stem. Iconographic evidence also provides an insight to stem and stern shapes, and their possible classification, as all river warships depicted from between circa 50-250 had a concave bow – convex stem configuration. Examples of what were most likely Roman military transports from the same period all have a convex bow – convex stem configuration (Chart 58), like that found in the later Type-B Mainz vessel. Unlike the hard chines forming a box-like cross-section in the hulls of lower Rhine vessels, the contemporaneous Oberstimm military vessels are much more rounded in section. These differences represent some of the disparity at the end of the second century between the northern European construction of the former with the Mediterranean construction of the latter. By the time of the construction of the fourth-century Mainz military vessels, there was a sharper transition from bottom to sides at the bilge, although still more rounded than that of the earlier riverboats.

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26 Although these vessels are separated by over two centuries, they are discussed as a set of evidence in order to demonstrate the different general construction characteristics of Roman military vessels and the varying types of vessels used by same Roman military. Höckman, “Roman Danube Vessels from Oberstimm, Germany,” pp. 217-223; Höckman, “Late Roman River Craft from Mainz, Germany,” pp. 29-30.

27 Although the full extent of the vessels’ ends were not excavated, the available material does not suggest that their ends were constructed to form abrupt terminations.

28 Personal communication with Dr. Frederick M. Hocker, June, 2000.

29 Höckman, “Late Roman River Craft from Mainz, Germany,” pp. 29-30.
from northern Europe. As will be discussed below, these military vessels from Mainz exhibited a preponderance of European construction characteristics, though they were certainly under the purview of the Roman army, and thus constitute a cultural hybrid.

**Internal Scantling**

**Longitudinal support: keels, posts, and central timbers**

During Late Antiquity, as in earlier periods, Mediterranean seagoing vessels were constructed with true keels. Keels were robust timbers that provided longitudinal strength to withstand the hogging and sagging tendencies of vessels. False keels, such as those possessed by the County Hall and seventh-century Yassada ships, were sometimes attached to the keel’s underside for protection and further reinforcement. Keels were sometimes rockered to further resist hogging and sagging forces. However, none of the vessels in this period have clear evidence of having a rockered keel. Ships built in the North Sea and Baltic regions had thick central planks in lieu of a true keel. For example, the Blackfriars ship had two keel planks each 33.0 x 7.6 centimeters, set side by side.

Keels were often rabbeted or chamfered to provide a flush surface for joining tightly with the edges of garboard strakes that rose off the keel at an angle. This was an important consideration in mortise-and-tenon based construction to provide parallel surfaces for the opposing mortises. Rabbets were found on the keels of the Monaco, Pointe de la Luque B, Fiumicino 4, and seventh-century Yassada ships, while chamfers were used on the Laurons 2 vessel. These cuts were not necessary if the garboard strakes were attached perpendicular to the keel or had little deadrise, such as on the County Hall vessel, or if mortise-and-tenon joinery was not employed, such as the Tantura A vessel that did exhibit deadrise.

Several trends in keel dimensions are evident during this period. Chart 7 shows that the general cross-sectional shape of keels as defined by their aspect coefficients (coefficient of molded to sided dimensions) does not appear to change over time, although it is observable that all keels had an aspect coefficient above 1.0, which indicates some vertical elongation of the keel, and by the fourth century keels begin attaining aspect coefficients of greater than 2.0. Chart 8 plots the aspect coefficients of keels against the estimated length of each vessel to account for the effect of overall ship size. The results do not show

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30 This development parallels that found in Mediterranean seagoing vessels, although it appears to have been temporally ahead in seagoing vessels.

31 Unlike the employment of keel-planks found in most indigenous-built craft operating in the North Sea and Baltic regions.


33 For example on the fourth-century BC Kyrenia ship: Steffy, *Wooden Ship Building*, p. 43.


any apparent relationship between vessel size and keel aspect coefficients. For the Mediterranean vessels, there was, however, a slight trend over time for increasing aspect coefficients of keels when discounting for vessel size, although this trend appears to possibly begin decreasing in the seventh century (Chart 9). Hence, it appears that some factor other than vessel size was driving the increase in keel aspect coefficients over time. Note the low keel aspect coefficient values for vessels indigenous to the North Sea and Baltic regions when compared to Mediterranean examples.

As was expected, there is a positive correlation between the cross-sectional area of keels and estimated ship length (Chart 11), thus necessitating the discounting of cross-sectional area by estimated vessel length. The keels of Late Antiquity seagoing vessels were increasing over time in robustness as shown in Chart 10, which plots the cross-sectional area of keels to estimated vessel length. Note the much lower values of Mediterranean vessels than those of contemporaneous North Sea vessels.

Unfortunately, posts are rarely preserved much above their junction with the keel. Where fragments have survived their dimensions indicate that these vertical timbers were typically as, or more, robust than their associated keels. A few examples are the Laurons 2 vessel, with a keel cross-section of 16.0 centimeters x 20.0 centimeters, stem of 13.0 centimeters x 17.0 centimeters, and a sternpost of 13.0 centimeters x 23.0 centimeters. Similarly the Bourse de Marseilles vessel had a keel and stem of 17.0-28.0 centimeters x 29.0 centimeters, and a sternpost measuring 25.0-35.0 centimeters x 35.0 centimeters. Stems and sternposts were timbers that secured strake ends and often had rabbets cut into their upper or interior surfaces to facilitate and strengthen the fastening of strake attachments. Examples from the Mediterranean region are the Laurons 2, Bourse de Marseilles, Fiumicino 4, fourth-century Yassuada, and Tantura A ships. Posts were also joined to the keel planks of North Sea vessels. The Blackfriar ship’s keel planks were fastened to a stem measuring 30.0 centimeters x 15.0 centimeters and a sternpost 15.0 centimeters x 6.3 centimeters. North Sea ships also had rabbets cut into their posts for strake attachment; examples include the Blackfriars, New Guy’s House, and Guernsey vessels.

In addition to the keel and endposts, central stringers and proto-keelson timbers also provided longitudinal strength to the hulls of Mediterranean seagoing vessels. Of the nine examples with sufficient

39 Marsden, Port of London, pp. 54, 98; Rule, “The Romano-Celtic ship excavated at St. Peter port, Guernsey,” pp. 52-54.
40 These were not true keelsons employed in ship construction, as they were not always attached to the posts and through some of the frames to the keel. However, I use the term ‘proto-keelson’ for the large longitudinal timbers located atop the frames centrally above the keel and attached through some frames to the keel. These differ from central stringers that lie to the outside of the keel center line. The intended
surviving evidence, four had a pair of central stringers that stretched from stem to stern (the Laurons 2, Bourse de Marseille, Port-Vendres 1, and Anse St. Gervais 2 ships), and four had proto-keelson timbers (the Monaco, Pointe de la Luque B, and both Yassiada ships). There is no apparent preference for either type of timber arrangement over time or by size of vessel. In the Bourse de Marseilles ship, a forward proto-keelson and an aft pair of central stringers together stretch from stem to sternpost. In two vessels, Bourse de Marseilles and Port-Vendres 1, the proto-keelson was notched to the top of the frames for a stronger union. Central stringers and proto-keelson timbers were typically fastened to the keel with large iron bolts or spikes, as in the Pantano Longarini, Anse St. Gervais 2, and seventh-century Yassiada vessels. In all examples where evidence was available, central stringers were connected to one another with inset chocks.

There is a distinct upward trend over time for the combined effect of the average cross-sectional area of the keel, proto-keelson, and central stringer timbers, as an indicator of the total central longitudinal support provided for in a vessel’s construction. In order to discern a pattern irrespective of a ship’s overall size, as larger vessels will likely have larger central support timbers (i.e., the positive correlations in Charts 11 and 12), a coefficient of the total cross-sectional area of longitudinal support to estimated vessel length was calculated and plotted in Chart 13. These values illustrate an increasing cross-sectional area of longitudinal support for ships from the fourth century onwards. The Tantura A vessel was included in this analysis even though it was uncertain as to whether a proto-keelson timber was present or not. If, indeed, a proto-keelson was present, with at least the same cross-sectional area as the keel, then it would plot very close to the trend line.

A considerable portion of longitudinal strength in indigenous-built North Sea vessels from Late Antiquity was provided by the thick keel planks, there being no extant examples of central stringers or proto-keelsons on these ship remains. When considering the coefficient of total keel plank cross-sectional area to length of vessels in comparison to the previous coefficients for Mediterranean seagoing vessels


(Chart 10), one notes significantly higher values for these North Sea vessels. However, this does not indicate increased longitudinal support for the vessel over their Mediterranean counterparts, since the flat shape of keel planks allows for less resistance to vertical flexing than true keels having the same cross-sectional area. Therefore, the shape of these timbers countered much of the strength inherent in their larger size, but since these vessels were obviously operational, their minimum strength needs were achieved by fully integrating the frames with the keel planks.

River craft having true keels rather than keel planks, include the Fiumicino, New Guy’s House, and Oberstimm, vessels.\(^4^4\) The coefficients of cross-sectional area of longitudinal support to estimated vessel length for keels of river vessels are on the whole less than those of Mediterranean seagoing vessels (Chart 14), although one observes a similar positive trend of increasing total cross-sectional area with estimated length (Chart 15). Additionally, the keels of river craft tended to have a trapezoidal cross section, with the greater dimension on the upper surface, compared to the more rectangular keels of seagoing vessels. A plot of keel aspect coefficients indicates no clear pattern over time (Chart 16); although, with the exception of the New Guy’s House Boat, the coefficients for all seven vessels examined yielded values of 1.0 or higher. Keel planks were also found in the Mainz River vessels, where a single thick strake ran down the center of each hull. These were the only river vessels to exhibit this feature. There were only two boats preserved sufficiently to have both dimensions recorded for proto-keelsons. Considering both the proto-keelsons of the Fiumicino 1 and 3 vessels, their coefficients of total cross-sectional area of central longitudinal support to estimated total length were 0.137 and 0.096 respectively, well below values for Mediterranean seagoing vessels (Chart 15).

Vessels excavated along the lower Rhine region had neither keels, keel planks, nor posts. Rather, they possess a series of very thick strakes that form a flat bottom, providing longitudinal support as a unit for these long, narrow craft. Calculating the coefficient of the entire bottom cross-section to total length of vessel for four of the river craft where sufficient evidence is available (Chart 17) provides values as high as and even above those of river vessels with keels and equivalent to those having keels and proto-keelsons. As with keel-planks however, the aspect coefficient of these timbers reduces the effective resistance to vertical flexing; and, indeed, these vessels appear to have been quite flexible craft. Offsetting some of this loss in stiffness were small timbers notched and attached centrally atop the frames in some vessels. These notched timbers acted in the manner of a proto-keelson or stringer. Such a configuration can be seen in the Zwammerdam 2 and 6 vessels.\(^4^5\)


Longitudinal support: stringers and attached ceiling

Further longitudinal support was obtained from attaching ceiling strakes or large stringer timbers longitudinally along the top sides of frames. The difference between what are referred to as attached ceiling versus stringers in some excavation reports, however, is ambiguous. Ceiling strakes are inserted to protect frames and hull planking from the cargo, to prevent cargo from disrupting the flow of bilge water, and to protect the cargo from being soaked by bilge water. Ceiling planks also protected the frames from larger ballast, and helped to prevent sand and gravel from working between planking seams. It is not necessary to attach ceiling strakes to provide these benefits, and ceiling planks were often left loose atop frames. When ceiling planks were attached to frames (at least to every other frame) they served an additional function similar to that of stringers in offering additional longitudinal stiffening. In general, stringers were more robust timbers than ceiling strakes and were always attached to the majority of frames.

Over this period of analysis there is no evident trend in a particular arrangement of attached ceiling versus stringers. Some earlier vessels employ between two and six stringers, although incomplete remains of many shipwrecks may render this range somewhat low. For example, the County Hall ship had only two stringers, which ran near its turn of the bilge, although, averaging 14.0 centimeters x 8.9 centimeters, they were robust for the vessel.46 Attached ceiling was found on the fourth-century Laurons 2, Yassıada, and Dramont F ships.47 Although typically not as robust as stringers, the large amount of attached ceiling employed, covering nearly the entire bottom area through the turn of the bilges, provided a significant amount of support for these vessels. A greater use of stringers is evident beginning in the fourth century. For example, the fourth-century Pointe de la Luque B and Dramont F vessels on the one hand, the c. 400 Port-Vendres 1 and seventh-century Yassıada vessels on the other, the latter two employed approximately sixteen and eighteen timbers respectively.48 Many of the eighteen robust timbers in the Yassıada ship were half-logs, which provided significant bottom coverage in the hold and, together with some squared stringers, performed the role of ceiling.49 The Yassıada vessel also had thick shelf clamps inboard of the wales for further stiffening. There was apparently an alternating pattern of loose ceiling planks with stringers in some excavated wrecks. The Bourse de Marseilles, Port-Vendres 1, and

46 Marsden, Port of London, p 118.
Pantano Longarini vessels each utilized this arrangement over a portion of their frames.50 Fragments of what appear to have been stringers survived in both the Bourse de Marseilles and Port-Vendres 1 ships, with average sided and molded measurements of 19.0 centimeters x 8.0 centimeters and 12.0 centimeters and 9.0 centimeters, respectively. To further secure stringers and frames to one another, there were often notches cut into the top surfaces of frames into which stringers were seated before attachment. Such an arrangement is found in the County Hall, Pointe de la Luque B, and Pantano Longarini vessels. By interlocking and better securing the frames and stringers, the support provided by each set of timbers was effectively increased and the stresses were more evenly distributed within the hull.

Longitudinal support: wales

Because sinking vessels come to rest predominately on their bottom and bilges, upper portions of hull sides are less likely to survive unless the vessel lists greatly to one side, or a side collapses and is quickly buried. Hence, from the period of study, there is good structural evidence for wales in only fifteen vessels. From this sample the number of preserved wales used on each vessel was between one and four. Eight of the ships were seagoing vessels, three of which come from the North Sea region. The Blackfriars and Gurnsey ships had no preserved wales, while the County Hall ship employed a single wale in its hull. Evidence from the five seagoing vessels from the Mediterranean, however, suggests a trend over time toward an increasing number of wales being used, but conclusions are tentative due to the incomplete preservation of hull structures. The third-century Bourse de Marseilles and fourth-century Laurons 2 ships each had two wales. This number increases to three wales in the fourth-century Pointe de la Luque B ship and sixth-century Pantano Longarini vessel, and to four wales in the seventh-century Yassiada ship. Seven of the fifteen archaeological examples were Roman military river craft. The Oberstimm 1 and 2 vessels possessed two wales and each Mainz vessels had a single wale. However, the Type-A Mainz vessels had inner and outer sheer wales joined together with a caprail attached above. Although river vessels from the lower Rhine did not have true wales, but their carved, thick 'L'-shaped bilge strakes with their hard chines acted in a similar fashion by providing longitudinal stiffness. Although wales were virtually always bolted or spiked to many of the frames in these examples, no large bolts or spikes were found in the small wale of the Pantano Longarini vessel.

Iconographic evidence is also an indicator of the presence and number of wales on vessels (Charts 49, 53, 56, and 60). For vessels that appear to be Mediterranean merchantmen, nineteen of those dated between circa 50-250 depict enough of the hull to determine the number of wales. Five ships each have zero, two, or three wales shown, and three vessels have only one wale depicted. A single vessel is shown with a total of five wales. From depictions dated to circa 250-450, twelve of the twenty-five ships

have two wales, and there are five depictions that have three wales. Four of the depictions have four wales, and a single example has one wale shown. In the period between circa 450-650, five of the eleven ship depictions have a single wale and only one example each have two and three wales. There are no ships in this time period depicted with more than three wales. The trend towards an increasing number of wales found in the archaeological record is paralleled in the iconographic evidence for at least the first two periods, but diverges in the last. Part of this divergence may be due to the nature iconographic examples for the period between circa 450-650, since changes in artistic styles during this later period entailed a lesser degree of detail than in earlier periods.

An opposite trend can be observed in the iconographic evidence for Mediterranean warships (Chart 53). Eighteen of the thirty-six examples from circa 50-250 have two wales; four vessels, no wales; six vessels, one wale; seven vessels, three wales; and one vessel has at least four wales shown. The twenty-five examples I found dated to the period between circa 250-450 exhibit a very different breakdown. Seventeen have no wales depicted; four ships, a single wale; two ships, two wales; and two ships with three wales. There were no examples shown with more than three wales.

Turning to the depictions of Roman river warships (Chart 56), we find that for the period between circa 50-250, six out of the eleven vessels have three wales; four, two wales; and one vessel, four wales. Among eight depictions of military transports from this period (Chart 58), five vessels have three wales and three vessels had two wales. Among the eleven depictions of river warships from the period from circa 250-450 (Chart 56), six vessels have no wales; two vessels, no wales; two vessels, two wales; and one vessel has three wales. In all, the iconographic evidence is in line with and supports the archaeological evidence for these vessel types. Eleven of twenty-two depictions of smaller utility vessels from the third to mid-fifth century (Chart 60) have a single wale and eight had two wales; the other depictions do not have wales represented.

**Transverse support: frames**

Frames serve as the primary internal timbers that provide transverse strength to ship hulls, and do so regardless of whether the frames are attached before or after the planking is in place. Although the sequence of attachment has little bearing on strength, it has great bearing on forming the shape of the hull. The structural integrity was greatly increased when the frames were secured to the keel and posts in addition to the planking. The spacing of framing timbers is another factor in providing hull strength. Fortunately, there are a good number of both seagoing and riverine vessels that can provide adequate archaeological data on framing for analysis.

A large portion of the data concerning frame dimensions and spacing is derived from seagoing vessels that operated in the Mediterranean region. In virtually every circumstance where evidence is clear, ships from this region had a pattern of alternating floors and half-frames. Futtocks were only rarely connected to the floors or half-frames; the Tantura A vessel possibly being a notable exception. The
County Hall vessel, built in Roman-controlled England but in many regards in the Mediterranean manner, might be regarded as another exception. Examining the size and placement of frames, as defined by their cross-sectional area and their center-to-center spacing respectively, several trends over the period under study. Chart 18 displays the coefficient of frame cross-sectional area to estimated vessel length for the Mediterranean seagoing vessels dating from the second to seventh centuries. The increasing trend in these values indicates that frames were generally becoming proportionally larger in vessels over time from the second to fourth centuries, then stabilizing through the seventh century. Excavation reports more often report sided dimensions; Chart 19 plots the raw average of sided dimension values over time, (including two from indigenous-built North Sea ships), and Chart 20 shows the coefficient of these sided values to estimated lengths for Mediterranean seagoing vessels. There is a similar discernable increasing trend in sided dimensions for the Mediterranean vessels in both charts, although these values were much lower than those for indigenous North Sea vessels.

Less variability is evident in center-to-center frame spacing (Chart 21) than in cross-sectional area, with all but one example from the Mediterranean falling within a range of 8.0 centimeters of one another. The increase in center-to-center spacing from the fourth/fifth century is largely due to the high value of the Pantano Longarini vessel, which often presents itself as an anomaly in comparative analyses of frame dimensions. More evidence is needed to determine, however, if there is a decreasing trend during the seventh century as this limited data suggests. In an attempt to remove the factor of overall vessel size on center-to-center spacing, the coefficient of spacing to vessel length was plotted in Chart 22. There is no observable pattern for these coefficients over time indicating that there was no trend for an increase or decrease in spacing over time. Again, note the comparatively high values of vessels from the North Sea region, which indicate a generally wider spacing between their larger frames. Chart 23 plots the estimated lengths of vessels to average frame spacing and shows a slight negative correlation for Mediterranean vessels whereby larger vessels had frames that were spaced slightly closer together. Note that the three outliers with frame spacing over 50.0 centimeters were all vessels operating in the North Sea region.

Trends observed in Charts 18 - 23 suggest that frames were getting larger through the fourth century, then stabilizing, while their center-to-center spacing remained roughly constant, which indirectly indicates that the open space between frames was decreasing. Charting the open space between frames over time in Mediterranean seagoing vessels (Chart 24), we find a pattern that mimics that of the frame spacing, however, when vessel length is factored into the equation (Chart 25), there appears to be no clear trend over time for the increasing of open space. There was a clear negative relationship between vessel

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52 Coefficient value = [Spacing (cm) / Length (cm)] x 100; the multiplier is used to achieve more workable figures.
length and open space between frames; slightly larger ships having less open space than smaller ones for the entire period. Thus, overall vessel size seems to be a strong determinant of open space between frames (Chart 26), indicating that larger vessels may have had their frames spaced slightly further apart than did smaller vessels. Chart 27 plots the frame cross-sectional area against open space between frames; the clear negative correlation indicates that spacing remained roughly constant while frames became larger.\footnote{Interestingly, the outlier in Chart 26 was the County Hall vessel; those of Chart 27 were again the County Hall vessel along with the Pantano Longarini ship.}

The coefficient of estimated number of frames to the estimated estimated length of vessel for Mediterranean seagoing ships (Chart 28) indicates that the number of frames per unit length possibly increased to a high point in the fourth century, but it does appear to decrease by the fifth century to a level consistent with what it was before the fourth century. Hence, other than the apparent increase in the number of frames during the fourth century, the number of frames did not vary over the period. The high density of frames in the fourth-century vessels such as the Laurons 2 ship, was possibly a consequence of bolstering the support provided by frames (frames were enlarging to this period) in attaining hull strength. Chart 29 includes the values for vessels operating in the North Sea as well. Note that the County Hall ship, built with many Mediterranean characteristics, has a value similar to those in the Mediterranean, while indigenous vessels have fewer frames per unit length than Mediterranean vessels. The typical configuration for the seagoing vessels in the North Sea region was a single heavy frame per frame station, with futtocks beginning at the turn of the bilge. The floors and futtocks in the Blackfriars ship were not attached, but they overlapped through at least one plank.

In analyzing frame dimensions and spacing in river craft, one perhaps should consider the geographical region in which they operated, thus by extension their cultural origins. Chart 30 groups the sided dimension values of river vessels according to the region in which their deposition occurred, that region presumably representing their general operational area. Most apparent are the greater sided dimensions of frames from vessels found in Britain and in the lower Rhine regions, all of which were indigenous-built craft likely used for commercial transportation. The remaining boats are either Roman military craft (Oberstimm and Mainz vessels) or Roman vessels used for transporting goods from Ostia up the Tiber to Rome (Fiumicino vessels). Examining the Roman military craft together, one sees a slight upward trend of sided frame dimensions over time, which is consistent with that seen in Mediterranean seagoing vessels. A plotting of cross-sectional area of frames against vessels length (Chart 31) shows a slight positive correlation for the Roman vessels. Generally, larger vessels had larger frames, but this correlation does not appear to be a particularly strong one. Plotting the open space between frames versus their cross-sectional area in these military vessels (Chart 32) provides no clear relation within Mediterranean or Northern indigenous-built craft, but there is a difference between the two cultural groups. As with Northern seagoing vessels, the Northern river craft featured larger and more widely
spaced frames than did Mediterranean vessels. However, some correlation between the open space between frames and their cross-sectional area may become apparent upon the accumulation of additional data.

Not only were the frames in Germanic vessels typically more robust than their Roman counterparts, some river craft had frames attached in pairs at each frame station. For example, the Druten, Woerden I and 2, Zwammerdam 4, Bevaix, and Kapel-Avazoath vessels all had pairs of frames at each frame station.\(^{54}\) When examining the number of frame stations to estimated overall vessel length coefficients for river vessels (Chart 33), one finds that the indigenous European river vessels generally have fewer frame stations per unit of vessel length than do examples of the Roman river craft. In contrast to these Germanic vessels, Roman river vessels had a single frame per frame station, typically with unattached futtocks. In a manner similar to that of indigenous-built craft from the North Sea region, the futtocks of the Type-A Mainz vessels also had a significant amount of overlap with the floor timbers. The Fiumicino vessels from Portus had floor timbers alternating with half-frames, the framing pattern we find in Mediterranean seagoing vessels.

Unfortunately, the recording of ships and publication of data has not been sufficient to make possible a quantitative study of the frequency in which frames were attached to the keel. Taking the available evidence as a whole, however, some general statements can be offered. In both examples of indigenous-built seagoing vessels from the North Sea region and all river vessels from the Rhine, Danube, and Britain, every frame was attached to the keel, keel planks, or bottom planking.

Evidence from sea and river vessels of the Mediterranean suggests an increasing tendency to fasten frames to the keel during the sixth and seventh centuries. The Bourse de Marseille ship of circa 200 had only seven of it nearly sixty frames (11.7%) attached to the keel with copper bolts. Likewise, the third-century Monaco vessel appears to have had only a few frames attached. In the fourth century, some vessels exhibit a slight increase in the percentage of frames attached to their keels, these being river craft. For example, the Fiumicino I vessel had five of forty-two frames (11.9%) attached and the Fiumicino 2 vessel had at least three, and up to six, of around forty frames (15.0%) attached with iron spikes. For seagoing vessels, the fourth-century Yassada ship had only six of its circa sixty-five frames (9.2%) attached, slightly fewer than the examples from the previous century. By the sixth century, a significant

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increase had taken place; all of the frames found in the Tantura A vessel were attached and possibly up to a quarter of the frames of the Pantano Longarini vessel were attached. This trend continued into the seventh century, where a third of the Anse St. Gervais 2 and at least a quarter of the Yassii ship’s frames were attached. Further integration of the frames and keel was attained by notching the frames onto the keel, a feature found, for example, on the Pointe de la Lucaque B and seventh-century Yassii ships.55

Planking

Strakes

Mediterranean watercraft often had strakes comprised of more than one plank. In most circumstances the garboard was a single timber, but from the second strake onwards it was quite common to have strakes composed of multiple planks. Conversely, some ships from the North Sea region had hulls constructed with all of their strakes made from single timbers such as the Blackfriars vessel. There were two main configurations of planking during the period, one where planks were aligned edge-to-edge, later termed ‘carvel’ construction, and one where the upper planks overlapped to the outside the lower planks. Depending on how these overlapped planks were fastened the terms ‘lapstrake’ or ‘clinker’ is often applied.56 In all but a few exceptions, the examples from the period examined have planks that are fastened edge-to-edge to some degree. Some river vessels from the lower Rhine have a single strake for extending the sides upward, such as the Zwammerdam 2 and 4 vessels.57 This strake is offset and slightly overlaps the large chine timber and is thus of ‘lapstrake’-type construction. To include these as ‘lapstrake’-type configurations is considered unconventional, but the planks do overlap, the principal characteristic of this construction style.

Planking thickness for Mediterranean seagoing vessels, excluding the typically much larger garboard strake, display some of the clearest trends in the period under study. Chart 34 indicates a reduction in planking thickness for ten vessels dated between the second and seventh centuries. Note the distinct reduction in thickness from around the third century and leveling off into the sixth and seventh centuries. In comparison, the few examples of indigenous-built seagoing vessels from the North Sea region had thinner planking than those of contemporary Mediterranean seagoing vessels (Chart 35).58

Unsurprisingly, there is a positive correlation between estimated vessel length and planking thickness (Chart 36), larger vessels tend to utilize thicker planking strakes. In order to eliminate the effect of overall vessel size on the analysis of planking thickness, the coefficient of ship-length to planking

55 Liou, Gallia 31 (1973): 582-584; Bass and van Doorninck, Jr., Yassi Ada, pp. 59-61, figs. 3-21 – 3-24. 56 ‘Lapstrake’ describes planks fastened with nails or trenails, while ‘clinker’ refers to planks fasted with rivets. However, for dealing with planking alone the term ‘lapstrake-type’ is an adequate descriptive term for all overlapping strakes. Personal communications with Dr. Frederick M. Hocker, June, 2000, and Dr. Frederick van Doorninck, Jr., May, 2001.
58 For example, the second-century Blackfriars vessel had planking ranging in thickness between 3.0 and 5.0 centimeters: Marsden, Port of London, p. 39.
thickness for Mediterranean seagoing vessels is presented in Chart 37. These values indicate a very gradual decrease in planking thickness until the fifth century when it then begins to decrease precipitously. Hence the sharp decrease observed in the raw planking thickness values of Chart 34 during the third and fourth centuries must be attributable to a decrease in vessel sizes during this period. The comparing of the planking coefficient value for the Blackfriars ship, at 4.9, reveals that indigenous-built North Sea vessels employed thinner planking per unit length of vessel than did their Mediterranean seagoing counterparts.

A trend is also evident when charting the planking thickness for river vessels grouped in their geographical region of deposition (Chart 38). Non-Roman river vessels from Germania Inferior had the thickest planking, while Roman river craft had thinner planking overall, with values falling between 2.0 centimeters and 4.0 centimeters. One possibly non-Roman craft, the New Guy’s House Boat from Britain, had an average planking thickness of 2.5 centimeters that is more characteristic of Roman river vessels. The Mainz river vessels (Roman military craft from circa 375) had the thinnest planking among river vessels. Charting the coefficient of planking thickness to estimated total ship length (Chart 39) indicates a thinning of planking for non-Roman and Roman craft alike over Late Antiquity. However, a more useful comparison is that among the Roman military vessels (Oberstimm and Mainz boats) which demonstrates a considerable thinning of planking from the beginning of the second to the end of the fourth century.59 Planking thickness and estimated vessel length were also plotted to demonstrate the effect of vessel size on planking thickness (Chart 40); interestingly the Mainz craft of different lengths have the same planking thickness.

Taken as a whole, a graph of the planking thickness of all seagoing and river vessels from the second to seventh century exhibits a clear downward trend toward thinner planking (Chart 41), though again much of this trend is associated with a decrease in overall vessel size until the fifth century when the decrease begins in earnest. This is evident when accounting for vessel size, where a reduction is evident over the entire time period under study (Chart 42), which indicates a general thinning of planking per unit length of vessel, although the most dramatic decrease in thickness began in the fifth century. Note also the greater range of plank thickness values during the earliest centuries, and their narrowing range in the later centuries for both charts. From this limited data, it seems that the fifth century through seventh centuries was a period when the most dramatic decrease in planking thickness took place.

The availability of extensive planking thickness measurements allows for an interesting assessment of these values against two measurement systems of Late Antiquity: the *uncii* and *uncii-Drassus*. Several problems are inherent in such an exercise and must be dealt with before looking at the results. A deviation from the intended thickness could have occurred during the original cutting, or

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59 As only two groups of vessels are available for comparison, the trend is offered here only as a hypothesis; however, such a trend would fit nicely with the evidence from Mediterranean seagoing vessels.
subsequent shaping of the plank. The wood itself may have increased or decreased in thickness during
taphonomic processes. Also, there is the potential error made by the excavator through insufficient
sampling, poor methodology, or simple mistakes. Furthermore, many thickness values are given as
ranges, and there is also a tendency to report them to the nearest centimeter; thus, a simple averaging these
reported ranges may result in inherent errors. Finally, there is the coincidence factor whereby a non-
measured plank may happen to have a thickness that is some multiple of a measurement system, not a rare
circumstance when dealing with such small units. Although these concerns render any conclusions
tentative, such an analysis still has interest.

Chart 43 shows the plot of planking thicknesses reported for various excavated vessels in terms
of uncii; Chart 44, in uncii-Drussus. A number of vessels have planking thickness of 1.0 uncii: the New
Guy’s House, Monaco, Fiumicino 4, all Mainz, and Tantura A vessels. It appears the Fiumicino 1 and 2
vessels may have used the uncii system, with values of 1.25 and 1.75 respectively, and values of 1.75 uncii
are derived for the Pointe de la Luque B, Dramont F, and Dor D vessels. For the Bourse de Marseille
vessel, the closest value is 2.5 uncii. De Weerd has maintained that the Zwammerdam vessels were built
on a Roman system of measurement. If so, only vessel 2 seems to have a plank thickness that could have
been measured in uncii with a value of 3.25; Arnold has effectively refuted much of de Weerd’s
arguements. As for the uncii-Drussus system, the seventh-century Yassuada vessel had a corresponding
value of 1.25, that of the fourth-century Yassuada vessel was 1.5, and the Torre Sgarranta vessel had a value
of 2.5. While it is certainly possible that the seventh-century Yassuada vessel may have used an early
Byzantine measurement system, the use of such a system would result in an awkward value of 1.31
Byzantine uncii. A heartening result is the lack of any apparent correlation of the Blackfriars vessel’s
planking to either system. Vessels that did not have values near a quarter denomination for either system
were the Oberstimm, Zwammerdam 4 and 6, Bourse de Marsilles, County Hall, Laurons 2, and Port
Vendres 1 vessels (Chart 45).

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60 Although other cultures may or may not have had measurement systems based on units near the uncii or
uncii-Drussus, they are not recorded or known to have been applied to construction in this period. Thus
testing for them would be spurious.
61 Marsden, Port of London, p. 99; Parker, Ancient Shipwrecks, pp. 178-179, 279-280; Kahanov and
5; Y. Kahanov and J. G. Royal, “Analysis of Hull Remains of the Dor D Vessel, Tantura Lagoon, Israel,”
International Journal of Nautical Archaeology 30 (2001): in press; Parker, Ancient Shipwrecks, pp. 168-169,
247.
63 Gassend, Lacydon, pp. 78-79; Parker, Ancient Shipwrecks, pp. 266-267.
64 de Weerd, “Ships of the Roman period at Zwammerdam/Nigrum Pullum, Germania Inferior,” pp. 16-20;
Parker, Ancient Shipwrecks, p. 459; B. Arnold, “Some Objections to the Link Between Gallo-Roman
Boats and the Roman Foot (pes montetalis),” International Journal of Nautical Archaeology 19 (1990):
273-277.
65 Note that the County Hall vessel, with possibly a hybrid of indigenous North Sea and Mediterranean
construction traits, did not conform to a Roman system and was operating in Britannia. Höckman, Roman
Another aspect of hull planking was the caulking used in strake seams. Ships operating in the North Sea had used caulking since the beginning of the period under study. Because the indigenous vessels did not utilize mortise-and-tenon joints, caulking could be wedged into the planking seams, for example in the case of the Blackfriars vessel. Caulking was not used in Mediterranean vessels, seagoing or river, between the second and fourth centuries. The practice of caulking is first seen on the Port Vendres 1 vessel, dated to c. 400, and later in the c. 500 Tantura A vessel. From the fifth century onwards, caulking of strake seams was also practiced for purposes other than shipbuilding. Maurice, in describing how to fashion a proper water cistern for maintaining water supplies during a siege, advises the use of thick planks shaped into a box with the seams and joints “sealed with pitch and tow or wicker…”

Planking scars within a strake have few variations in the period under study. Vessels from the North Sea region have minimal plank scarfing, as their strakes were often fashioned from single lengths of timber, such as those of the Blackfriars vessel. Where keel-planks or other planks were scarfed, simple butt joints appear to be the preferred method. Mediterranean vessels, on the other hand, typically had some strakes comprised of several planks that required scarfing. Diagonal through scars were those most commonly employed for this purpose, and were predominately used in the Bourse de Marseilles, Laurons 2, Port-Vendres 1, seventh-century Yassada, and Dor D vessels, while diagonal stop scars were used in the County Hall ship. The only two variations to the diagonal through type were the curved scars used in the fourth-century Yassada ship and the butt scars used in the Tantura A vessel.

Planking scars extended anywhere from two to five frame stations, and scarf ends tended to terminate on a frame so that they could be secured to it. Additional securing on scarf ends was also used, as in the County Hall and seventh-century Yassada ships, where nails were driven although the scarf ends to the adjacent planks. Mortise-and-tenon joints were sometimes used to join planks to one another. If the scarf was sufficiently long, these joints could be of the same size and spacing as the joints used between strakes. If the scarf was quite short, typically smaller and fewer mortise-and-tenon joints were used to secure the planks to one another. Mortise-and-tenon joints in a scarf were often oriented in the same


Marsden, Port of London, p. 40. As stated in the Introduction, the lapstrake shipbuilding techniques of some cultures in the North Sea are not addressed in this study.


Maurice, Strategicon, 10.4.

direction as the mortise-and-tenon joints adjoining the strake in which the scarf was located. In this case, they were set at an angle to the scarf seam. Such mortise-and-tenon joints were found on in the fourth and seventh-century Yassiada ships. Mortise-and-tenon joints could also be set perpendicular to the scarf cut, as in the Dor D vessel. There appears to be a conscious effort made by shipwrights to avoid placing scarfs at the same frame station in neighboring strakes, in order to prevent a potentially weak spot in the hull created by the concentration of scarfs.

**Fastenings**

There were two basic methods of fastening strakes to the hull: the attachment of one strake to another and the attachment of strakes to frames. Through the use of either or some combination of these two methods, several fastening configurations were possible: planks were fastened to one another on their edges, planks were fastened at their overlaps, and planks and frames were joined to one another. To solve problems encountered in shaping a hull, a variety of configurations, types, and materials were employed in the vessels of Late Antiquity.

Only the Blackfriars and Guernsey vessels from the North Sea region employed a method where strakes were attached only to the erected frames and not to one another. In both examples, iron nails were driven through treenails from outside of the hull. The treenails, in turn, had been driven through drilled holes, and the nails were double-clenched onto the inner surfaces of the frames to secure them. Double clenching held the nails firmly in place, and the use of treenails reduced the potential splitting of the framing and planking timbers. Although the overwhelming majority of examples of vessels employing mortise-and-tenon joints were from the Mediterranean region, such joints were also seen in vessels further to the north. For example, hull planks of the County Hall, Zwammerdam 6, and Vechten vessels were fastened with mortise-and-tenon joints.

Mediterranean seagoing vessels utilized a mixture of the methods in the fastening of their strakes, although almost all vessels had at least some strakes that were edge joined. Planks were typically attached at their edges with either pegged or unpegged mortise-and-tenon joints. Continuing a long tradition dating

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70 Note that the sole pegged joint in the Dor D vessel was located on the planking scarf: Kahanov and Royal, *International Journal of Nautical Archaeology*, in press.

71 In the Blackfriars ship treenails were driven into holes drilled through the frames. A smaller hole was then drilled through each treenail and the adjoining point on the plank to be fastened into place, and a nail was driven from the outside through the hole in the two timbers and double clenched on the inner face of the frame. Treenails were cut so that the wood grain ran in line with their long axes, since a nail driven along the grain is less likely to split the wood. If nails had been driven without benefit of treenails, the grain of planking and framing timbers would almost always have been perpendicular to the nail. Furthermore, when swelled with water, the treenail fits more tightly in the drilled hole and constricts around the nail further securing the attachment. Marsden, *Port of London*, p. 48.

back to the Bronze Age, Mediterranean vessels from the second through fourth centuries all had pegged mortise-and-tenon joints, except for the Fiumicino 1 and 2 vessels, which had a few unpegged joints.\textsuperscript{73} Unfortunately, insufficient data prevents analysis of the fifth-century vessels with mortise-and-tenon joints, but fastening evidence for the sixth and seventh centuries suggests mortise-and-tenon joints were by that time typically unpegged. While the Anse St. Gervais 2 ship had a few pegged and mostly unpegged small joints, the Pantano Longarini, Yassada, and Dor D vessels had small, unpegged tenons that did not fill their mortises.\textsuperscript{74} A single pegged mortise-and-tenon joint found on the Dor D vessel, however, was employed to fasten a plank scarf. In some vessels, the purpose of the mortise-and-tenon joints was not to join the planking together, rather they were used as alignment aids during the attachment of strakes to the frames. A good example of this use of joints is found in the seventh-century Yassada vessel. Since unpegged mortise-and-tenon joints could not alone prevent the planks from pulling apart, further measures were required to secure the strakes in place, typically the fastening of the strakes to the frames. Interestingly, pegged mortise-and-tenon joints continued as a method of fastening in carpentry during the sixth century as evidenced by a chair and bed from a burial dated to circa 537 in the Prince of Cologne Cathedral.\textsuperscript{75}

There is a sufficient amount of mortise-and-tenon joint data from well-recorded and reported shipwrecks to allow for quantitative analyses. Several trends clearly take place over the period from the second to seventh centuries. The total joint size is reduced, the tenons become smaller in relation to their mortises, the spacing between joints is increased, and there is a move from pegged to unpegged joints. The general nature of these trends has been noted earlier by J. Richard Steffy and Frederick van Doorninck, Jr., and others.\textsuperscript{76} It is the goal of this analysis to provide quantitative descriptions of these trends and provide a better chronological framework for these changes.

Chart 46 depicts the average volumes of mortises and tenons in cubic centimeters as a clear indicator of their sizes. There is a distinct downward trend in the volumes of both, although tenon volumes appear to reduce at a slightly advanced rate over time. After the third century, average mortise sizes never came within about 50% of the values occurring in the second century; and, average tenon sizes were around 10% to 25% of their earlier values. Tenon sizes appear to have approached their minimum utility size by the sixth century. There is also a reduction in the range of values after the fourth century,

\textsuperscript{73} These joints may have been part of repairs to the vessel: Parker, \textit{Ancient Shipwrecks}, pp. 178-179.
\textsuperscript{75} E. James, \textit{The Franks}, p. 154.
but mortise sizes decrease further and tenons approach the size of those in use during the seventh century. Hence, the tenons seem to have reduced in size at a greater rate than to their mortises. Data from excavation reports and wrecks personally examined indicate that tenon thickness, on the other hand, remained virtually the same as mortise thickness. The majority of the size differential was in the tenon width versus the mortise width. Examining these size values shows that from the fourth century onwards, typically 55% to 65% of the mortise width was occupied by the tenon width (Chart 47). Furthermore, instead of a gradual decrease in the relative sizes of mortises and tenons, there is a sharp break in the pattern sometime in the fourth century. Vessels from the second and third centuries had tenons that fit snugly in their mortises, but when tenons started to become smaller than their mortises, they apparently reduced rapidly and drastically in size.

Average center-to-center spacing of mortise-and-tenon joints found in seagoing vessels are shown in Chart 48. Where applicable, the maximum and minimum values of some vessels are given; these are based on two averages taken from different parts of the hull, usually amidships and the extremities. Note that these maximum and minimum values are quite disparate for the seventh-century Yassuada and Dor D vessels. It is after the fourth century that the average spacing values begin to significantly increase. Note also the greater joint spacing in the County Hall vessel relative to that of other vessels of the same age; this is the only ship in the group that did not operate in the Mediterranean region.  

Mortise-and-tenon joinery was not the only method for strake attachment. The Fiumicino I river craft had repairs in its hull that used only nails, and the keel-garboard junction was similarly reinforced with nails. Vessels with unpegged mortise-and-tenon joints relied on securing the planks directly to the frames to keep them in place. Strakes between the wales of the seventh-century Yassuada vessel were also only nailed to the frames; likewise, no mortise-and-tenon joints were discovered in the Tantura A ship, with iron nails joining planks and frames. Although mortise-and-tenon joints joined the garboards to the keel and subsequent strakes to one another, the strake ends were nailed to the end posts of the Pointe de la Luque B, Monaco, and fourth-century Yassuada ships. Nailing was also used to supplement mortise-and-tenon joinery, as in the Monaco ship where bronze nails helped secure the garboard to the keel.

Frames always rested directly against the hull planking in Mediterranean seagoing vessels, and were attached with a variety of fastening types and materials. The method of driving nails through treenails was used as late as the fourth-century Laurons 2 ship, but is unknown in archaeological finds after this period. The nails used in early vessels were of non-ferrous materials such as copper or bronze.

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as in both the fourth-century Héliopolis 1 and Laurons 2 vessels. Copper gave way to iron for nail fastenings after the fourth century. Iron nails used alone to fasten planks and frames were found in the fourth-century Skerki Bank, sixth-century Pantano Longarini and Tantura A, and seventh-century Yassada vessels. Using only treenails to join planks and frames was also a common method and continued throughout this period alongside nailing, although nailing appears to have been the favored method from the fifth century onwards. Treenails were utilized in the third-century Bourse de Marseilles and County Hall ships, in the fourth-century Dramont F, Pointe de la Luque B, and Yassada ships, the sixth-century Anse St. Gervais 2 ship, and in the seventh-century Dor D vessel. Although treenails were used for frame-plank fastening in the fourth-century Yassada vessel, large nails were employed to attach the wales and frames.

Scarfin

Longitudinal timbers

Important areas of timber scarfin were the transition from the keel to end posts, and the joining of keel sections in ships with multiple keel timbers. Fortunately, there is sufficient evidence for these scars in the archaeological record throughout the entire time period in consideration to gain a good understanding of techniques employed. Generally, each example had scars that were variations on two basic methods: flat scars and hook scars. The primary difference between these scars was that the timber ends in hook scars were offset to prevent each from pulling away longitudinally from one another. Furthermore, hook scars had interlocking cuts to prevent the transverse movement of two timbers relative to one another. Flat scars did not have these innate elements that prevented separation in the vertical or transverse directions.

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84 Builders of indigenous Rhine river vessels did not have to contend with the joining of large central timbers since these vessels lacked keels and posts.
A survey of Mediterranean vessels suggests the hook scarf was most commonly employed for joining the keel to the end posts (Figure 2). An exception is the Bourse de Marseille ship, which did not have the interlocking cuts typical of hookscarfs; instead, the cuts simply overlapped and the keel ended in a mortise that locked into the terminus of the post. A large bolt was driven vertically through this scarf to provide resistance to shear forces, while vertical and transverse separation were addressed by the mortise joint. A similar solution was employed in the scarfs of the Fiumicino 2 and 4 vessels. In the Tantura A vessel, a single fastening hole passed through a flat scarf; this hole was larger than typical nail holes and may have been for a spike. Additionally, the largest frame in the vessel sat in a notch cut into the upper surface of the keel above this scarf. Similarly, a single bolt passed through the keel-sternpost scarf and continued through an overlying frame in the seventh-century Yassada vessel.

More sophisticated hook scarfs were utilized in the eight vessels for which we have adequate evidence, with at least seven of them having clearly employed keys in these hook scarfs. These scarfs exhibited one or more mortise cuts that served to interlock the timbers, thereby preventing vertical separation or the opening of the scarfs. These interlocking cuts were found on both the keel and post ends in each ship except the Tantura A vessel, where the post ended in a simple stopwater. The Port-Vendres 1 and the fourth- and seventh-century Yassada vessels each had interlocking cuts that prevented transverse movement of the timbers. Deadwood was fastened over the keel-post scarfs in the Port-Vendres 1 vessel to further strengthen the joints. As with the Bourse de Marseille vessel, each of the hook scarfs of the other seven vessels were configured so that the keel portion was situated underneath the post, and at least a single bolt was used to secure the scarf.

Typically, keels were fashioned from a single timber in order to ensure the strongest possible longitudinal support. However, the small Tantura A vessel is one example where the keel was made of two separate pieces joined by a simple flat scarf. Four nail holes were located on the keel surface above this 26.0-centimeter long scarf, and a possible bolt head found on the bottom keel face indicated a fastening through its center to secure it. The presence of a frame station here suggests that the fastenings possibly passed through the frame positioned above the scarf for additional strength.

Frames and futtocks

Although rare during this period, frames were sometimes scarfed to futtocks. The scarfing of frames and futtocks is typically associated with the pre-erection of frames before placement of strakes, but can also occur in other modes of construction. The earliest examples are the two scarfed frames and futtocks in the third-century County Hall vessel from Britain in which the frames appear to be added after the majority of the hull planks were in place. The fourth-century Mainz B-3 river craft also had its frames

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85 These are the Bourse de Marsailles, Monaco, Pointe de la Luque B, Port Vendres 1, fourth-century Yassada, Héliopolis 1, Tantura A, and seventh-century Yassada vessels.
86 It is unknown if the Héliopolis 1 ship possessed a key as well because of the limited remains.
and futtocks scarfed together. However, this vessel was not built with mortise-and-tenon joints and likely had its frames placed into the hull after forms had been utilized to temporarily hold the hull planks in place. Similarly, the small sixth-century Tantura A vessel had evidence of frame-futtock scarfing in the few surviving timbers. No mortise-and-tenon joints were found in this vessel either, nor was there any evidence of temporary forms, thus it probably had its frames in place before the majority of its planking was attached. In other vessels from the period, futtocks may overlap frames for several strakes, but they were not adjacent to one another. In the seventh-century Yassada ship the futtocks were in alignment with floor timbers and/or half-frames.

**Propulsion**

**Mediterranean merchantmen**

There were four primary methods of propulsion that were used during Late Antiquity: sailing, rowing, towing, and paddling. Propulsion is one of the more difficult aspects of seafaring to address, since archaeological evidence for masts, sails, rigging, oars, and paddles rarely survive. Despite the odd block fragment or toggle sometimes preserved amidst a wreck, conclusions on propulsion are frequently inferred from other characteristics of the ship or from supplementary forms of evidence. Combining iconographic and historical data with ship remains provides a plausible overview of propulsion methods for different types of watercraft. The data is arranged within three categories of vessels for discussion: merchantmen, military ships, and utility vessels.

Available evidence suggests that merchantmen in the Mediterranean used sails as their primary, although not exclusive, mode of propulsion. Masts were erected into maststeps, large timbers that had a mortise cut in their upper surface in which the heel of the mast was placed. Typically, beams (partners) forward of the mast in the upper portion of the hull would assist in supporting the forward force of the mast. Archaeological evidence for sailing includes a small number of maststeps, with only four examples having well recorded timbers. A large proto-keelson timber seated on the frames was notched on its upper surface to serve as the maststep in the c. 400 Port-Vendres 1 ship. The third-century Bourse de Marseilles, fourth-century Pointe de la Luque B and Laurons 2 ships each had a robust timber serving as a maststep situated between their central stringers. Large rectangular mortises were cut into the upper surface of each for the seating of the mast heel. There were also mortises cut on the top of the central stringers; these were in line with the maststep mortise and held stanchions for the mast partners. As the

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87 Höckman, “Late Roman River Craft from Mainz, Germany,” p. 31.
89 Such partners were also found in the Oberstimm vessels. Höckman, “Late Roman River Craft from Mainz, Germany,” pp. 219-223; Parker, *Ancient Shipwrecks*, p. 291.
sided dimensions of the maststeps for each of the aforementioned three shipwrecks were greater than the
open space between their respective central stringers, the bottom edges of the maststeps were rabbeted in
order for them to fit into place.

Unfortunately, archaeological evidence is not adequate enough to determine the numbers and
features of masts, sails, or rigging that ships typically carried during this period. A ship’s keel dimensions
and design are inadequate indicators of its rigging configuration. No correlation between design and mast
member or placement has been sufficiently established for the period under consideration in a manner that
can be reliably applied to archaeological finds in the Mediterranean or northern Europe. Maststeps have
been found on vessels ranging from those without any keel (such as the Blackfriars ship) to those with
substantial keels (such as the Laurons 2 vessel). Ship depictions from iconography can offer some insight
into these questions. In the charts accompanying this study where individual depictions are analyzed, each
rigging element has been categorized and tallied if it were clearly represented. For each depiction,
multiple elements such as rigging lines, deck structures, and decorative elements have been entered as
present or absent. Furthermore, the minimum presence of an element anywhere on the vessel resulted in it
being counted as present for that specific ship depiction. For example, if a ship depiction had two masts
and only one of them had shrouds, ‘shrouds’ were considered present for that specific depiction. When
the artist’s intentions were in question, one preferred to err on the side of conservativeness by not
attempting to interpret them, but simply accept that the artist undoubtedly omitted details for aesthetic
reasons. Hence, the tallies are likely to under-represent actual elements than over represent them. The
data is separated into three periods as discussed in Chapter II: circa 50-250, circa 250-450, and circa 450-
650.

Depictions from circa 50-250 had several mast configurations for the eighteen Mediterranean
merchantman depicted (Chart 49). There were eight examples each of ships having one or two masts.
One vessel possessed three masts and one ship was shown without any mast. Thus, over 55% of the
examples were depicted with more than one mast. Although it is impossible to estimate vessel sizes with
any certainty in iconographic representations, it can safely be presumed that vessels with multiple masts
are larger than those with single masts. In every instance of a vessel with two masts, and in the case of the
three-masted ship, one of the masts was located in the bow. This mast located at the bow was undoubtedly
the artemon. For the seventeen sails depicted, over 80% were square in shape and set below a single yard;
there were two instances of a spritsail and one of a lateen rig in the period. Although the main rigging
lines were well represented, sheets and brails were particularly often illustrated, with braces and stays
slightly less so. In contrast, halyards and backstays were present in only 18% and 35% of the ships,
respectively. In addition to the rigging, three of the seventeen vessel depictions had a rope ladder running
up the mast. A ladder was a most crucial element for operating the rigging of a vessel, and its rarity in
iconography illustrates how certain rigging and construction elements were under-represented by artists.
In the period between circa 250-450, there was a transformation in the numbers of masts in depictions (Chart 49). All twenty-one examples had either one or two masts, but now a slight majority (over 52%) had a single mast. In each of the eight two-masted depictions, the *artemon* was one of the two masts represented. In one instance of a single-masted ship the mast was the *artemon*, thus I considered the ship to be a two-masted vessel as it is very unlikely that only an *artemon* would be carried on a vessel without a mainsail. Square sails were also prominent in this period, with fifteen of the sixteen representations showing them. The only variant was a single example of a spritsail rig. Similar to the previous period, individual rigging lines were well represented in depictions between circa 250-450, with sheets, lifts, and braces most often illustrated. The rigging lines that were least depicted during the previous period, the halyards, were now present in six of the twenty-one examples from this period.

The ten examples from between circa 450-650 (Chart 49) show a continuation of the trend towards a single mast characteristic of the earlier two periods. All of these depictions had a single mast with a square sail, although generally fewer rigging lines were represented. The brail lines were well represented in this period, and are shown in five of the ten examples. However, lifts and sheets experienced the greatest drop in frequency from the previous periods, the former becoming entirely absent, while shrouds and braces also disappeared during this period. Likewise, compared to examples in previous periods, the frequency of sheets falls to only appearing in two of the ten examples after circa 450. Obviously, rigging lines were required in this period on ships, but their absence was possibly due to a general decrease in the representation of more minute details in artistic works.

A few merchantmen from the periods of circa 50-250 and circa 250-450 were depicted with oars in addition to sails. One of the two depictions from circa 50-250 had a single bank of oars and two masts, while the other ship had a single bank of oars but no mast. In the period of circa 250-450, two vessels were shown with a single bank of oars in addition to one mast. No oars were present in merchantman representations between circa 450-650.

**Mediterranean warships**

Warships illustrated in Late Antiquity were predominately shown with oars, but numerous examples also had masts. From the period of circa 50-250, thirty-three examples had a sufficient amount of the ship represented to ascertain the number of masts present (Chart 52). Of these, sixteen had no masts shown, while fourteen had a single mast depicted. Of the fourteen single-masted vessels, all but one example depicted what was an *artemon*. A single example from the period was clearly depicted with two masts, one a larger main mast located amidships and the other an *artemon*. All struck sails were clearly square sails set on a single yard. Among the rigging lines depicted, only lifts were commonly shown, other rigging occurred in only two depictions. The warship illustrations from period of circa 250-450 show a variation in the number of masts depicted (Chart 52). Of the twenty-five examples, fourteen (virtually the same percentage as the previous period) had no mast shown. However, seven vessels from
this period had a single mast, while four were shown with two masts. The presence of the *artemon* in 35% of examples in the previous period drops to only four of the twenty-five examples (16%) in this period. Also in contrast to the earlier period, the *artemon* never appeared alone, but only in conjunction with the main mast. Square sails were ubiquitous in this later period and the depictions of rigging greatly increased, especially of lifts, sheets, brails, back and forestays.  

Longus, writing in the fourth/fifth century, alluded to warships that were both rowed and sailed. However, he also mentions that a group of raiders in rowed vessels without sails were stranded due to the rough winter seas, which may be taken as evidence that not all ships employed both modes of propulsion. Although no useful depictions of warships dating between circa 450 – 650 were available, Maurice mentions sailing warships in the late sixth/ early seventh century.  

Oars are the most common method of propulsion associated with warships by scholars in Late Antiquity, undoubtedly founded on their frequent association in depictions throughout antiquity and from the oft-studied works of Hellenistic writers. Later writers also frequently refer to oar-propelled warships. For example, Alciphron mentions a Corycian vessel with many oars manned by pirates from Lycia. Additionally, Longus writes that soldiers manned the oars of their ship and sang songs while rowing, presumably to keep time. The questions that arise regarding oared propulsion are how many oars were used, how many oarsmen were typically employed, and how many levels of oarsmen were on warships. Without direct archaeological evidence, iconographic and written evidence must be brought to bear on these questions. In depictions from the first and second periods, every vessel has a single bank of oars. In every instance where rowers are depicted, only a single level of rowers is visible. It seems unlikely that artists attempted to produce technically exacting representations, but also likely that they attempted to roughly correlate the number of rowers with oars shown and represent a reasonable number of either to power a vessel. Artists were likely to under-represent the number of oars and oarsmen for a warship due to the confusing visual depiction of numerous oars and the difficulty of representing such fine detail in media such as mosaics. In the set of iconographic examples from both periods, the range of oars, calculated by simply doubling the numbers shown, is between eight and sixty. One would assume that the upper end of this range represents the largest of oared warships, as it is unlikely that more oars were shown than actually existed.

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92 A copied scene of Aeneas ships from a Roman villa in Britain proves problematic for analysis. Because the representation was imported, grossly anachronistic, and possessed such unrealistic depictions of ship elements (for example diamond-shaped sails), it was excluded from the statistical analysis. Note interestingly that it does have sails and a single-bank of oars shown together: J. Toynbee, *Art in Britain Under the Romans*, pp. 241-246.


95 Alciphron, *Letters*, 1.8. Care must be taken here as Alciphron has a tendency to quote from earlier periods.

Aelian refers to a fifty-oared warship from around 200 that provides some idea about one warship.\textsuperscript{97} This number of oars would imply twenty-five oars per side and presumably one oarsman per oar. Hence, this passage corresponds well with the upper end of the range of oars found in the iconographic record. Considering that a vessel with twenty-five oarsmen per side would have a minimum length of around thirty-five meters, the passage by Aelian also correlates nicely with the archaeological evidence for ship sizes in the Mediterranean around 200.

In the warship depictions, the oars passed through portholes in the side of the vessel (see Iconographic Example 21) or over the sheerwale (see Iconographic Example 20). Casson describes what appears to be a "rowing frame", or what I determine to be an outboard-gangway, often found on Roman Republican representations, although the oars consistently pass through portholes below this frame.\textsuperscript{98} There appears to be a similar type of configuration into the Imperial period (see Iconographic Example 19), though not as ubiquitously represented. Examining the third-century tombstone carving of a river warship from Neumagen/Mosel (see Iconographic Example 28), this feature may have a function independent of oar function and help to explain Casson's observation of the oars' apparent unrelated juxtaposition with the frame. Casson noted that the function of this projection may have been that of a bumper to protect the oarsmen and oars during naval engagements with other vessels, serving also as a "jumping-off point for marines preparing to board" another vessel.\textsuperscript{99} The function of such projecting frames on warships in riverine settings as a protective device during naval battles is unlikely. However, its use as a boarding platform would be consistent with both riverine and sea settings, not just in instances of battle, but when boarding or debarking vessels near shore or at dock as well. Furthermore, this outboard-gangway may have also served to facilitate movement of individuals fore and aft without having to contend with the working oarsmen. These outboard-gangways also appear to be integrated with the first wale below the sheerwale, a logical position to provide an adequate attachment point for this structure.

\textbf{Merchant and military craft from inland waterways}

Cargo vessels operating in both river and lake environments utilized the full gamut of propulsion methods. River and lake craft typically operated over shorter distances than sea vessels, and often faced more predictable environmental phenomena, such as steady winds and currents. These natural elements provided consistent propulsive forces for vessels when traveling in the proper direction but were often an obstacle when traveling against them. Therefore, the operators of river vessels often utilized two or more propulsion methods.

\textsuperscript{97} Aelian, \textit{Historical Miscellany}, 8.17.
\textsuperscript{98} Casson, \textit{Ships and Seamanship}, pp. 143-145. Such a structure could also have been constructed to serve both functions as well.
\textsuperscript{99} Ibid.
As at sea, the sail was used whenever possible in inland environments to conserve manpower and the labor of beasts. Aelian observed that river vessels had sails, and excavated maststeps from vessels such as the Bevaix, Oberstimm 1 and 2, Zwammerdam 4 and 6, Fiumicino 1, and Mainz B-3 boats confirm that sails were commonly used. River travel involved currents that sometimes rendered wind direction and vessel speed ineffective and unreliable. Thus, vessels with sails were also rowed or paddled to overcome currents when the wind direction was of no assistance or the wind simply insufficient. River craft showing evidence for both sailing and rowing or paddling include the Oberstimm and Mainz vessels; both, interestingly, were Roman military craft. Iconographic evidence also supports the combination of methods (Charts 55 and 60). In the examples of merchant craft, four vessels appear to be rowed and sailed and three were paddled and sailed. Of the ten military river craft depictions, two have both mast and oars, and in each case a square sail was set below a single yard.

Whereas large longitudinal timbers formed maststeps in Mediterranean ships, robust framing timbers served as maststeps in European inland craft. For example, the maststeps of the Zwammerdam 4 and 6, Bruges, and Bevaix boats were simply rectangular mortises cut into the upper molded face of oversized framing timbers, analogous to those of seagoing vessels in the North Sea region. The mortise for the mast was placed forward on the Bruge boat’s floor timber, as was done in the Blackfriars ship, probably in an effort to offset the aft force of the mast. Maststep-frames in these river craft were typically placed less than a third of the vessel’s total length from the bow. Such mast placements were forward of those found on typical seagoing ships. Having a forward mast placement not only allowed more control of these typically long vessels (high length-to-beam coefficients), but may have also permitted a rapid switch to towed propulsion when necessary. The Oberstimm and Fiumicino vessels from the Danube and Tiber regions, respectively, utilized an arrangement similar to Mediterranean seagoing vessels. Here mortises were cut into the surface of a proto-keelson timber that was attached to the tops of the frames. Although it seems likely that some of the Fiumicino vessels were towed, it is

104 Values for a sample of river craft, in percentage of frame distance from bow to total length of boat: Mainz A = 32.5%, Mainz B = 31.8%, Bevaix = 30.0%. Höckman, “Late Roman River Craft from Mainz, Germany,” fig. 1; Arnold, “The heritage of logboats and Gallo-Roman boats of Lake Neuchâtel: Technology and typology,” fig. 6.7; Parker, Ancient Shipwrecks, pp. 253-254.
105 Höckman, “Roman Danube vessels from Oberstimm, Germany,” pp. 218-221; Parker, Ancient Shipwrecks, pp. 178-179.
possible that in order to venture into the open harbor sail propulsion was also used on some craft engaged in lighter work. The placement of the maststep in the Fiumicino 1 vessel is forward of the center of gravity and could have served for either sailing or towing.

Towing was a useful method of propulsion for overcoming river currents or when wind was not available or reliable. It reduced manpower needs by allowing a beast of burden to take the place of rowers or paddlers. Moreover, fewer men were needed to tow a vessel than to row it. However, towing was limited to stretches of river where uninterrupted roadway or path of sufficient quality could be maintained along the bank. Towing masts, which were placed further forward in the hull than masts for sailing, were used to secure the towline to the boats. Typically, they were placed about a quarter of the ship's length from the bow, as seen in the Zwammerdam 2 vessel.106 This forward placement of the mast made the vessel easier to maneuver by moving the center of propulsive force further forward, thereby preventing the bow from easily veering off course.

River craft outfitted for rowing included the Mainz and Oberstimm vessels. In reconstruction of the Oberstimm 1 and 2 vessels, a total of sixteen rowers were proposed for each. Type-A Mainz boats probably had thirty rowers each, with oars on tholepins that were fixed to the reinforced inner-outer sheerwale and caprail complex. The smaller Type-B vessel was reconstructed with fourteen rowers. All but one set of military vessel depictions from circa 50-250, and all depictions from circa 250-450, had only oared propulsion shown.107 A relief from an early third-century tombstone found near Neumagen, Germany, depicted a single-banked military vessel with twenty-two oars per side, very similar to the Mainz Type-A craft.108 From the period circa 50-250, nine of the eleven vessels had two banks of oars. One of the latter possessed an odd and irregular arrangement of oars, rather carelessly portrayed, that appeared to span two or three possible levels, but were not rendered with adequate clarity to assuredly represent a multi-banked vessel. Overall, the oars on this vessel appear to be haphazardly assigned to banks without regard to their true representation in comparison to other warships depicted on Trajan's column. In all the two-banked examples, oars were not placed in the same horizontal plane, but alternately spaced in that no oar position was directly over or under another. The highest level of oars appeared on the sheerwale, while the lower oars appeared to pierce the hull. One problem with the examples from circa 50-250 is that the majority of the eleven depictions for the period are from Trajan's column.

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106 Value for a sample of river craft given in percentage of maststep distance from the bow to total length of boat: Zwammerdam 2 = 25%. de Weerd, "Ships of the Roman period at Zwammerdam/Nigrum Pullum, Germania Inferior," pp. 16-17.
107 Illustrations of military river vessels after c. 450 proved difficult to locate.
including the vessel with the carelessly rendered oars. Thus, there is a greater possibility of a single artist or artistic plan that influenced this data set.

In addition to the warships, several transport vessels from the Danubian campaign were also depicted on Trajan's column. As these boats were within the context of military operation, they were presumably part of the fleet or were possibly local vessels pressed into Roman service. Of the eight vessels shown, only one indicated a form of propulsion with a single bank of oars shown. No indication of sailing or towing is discernable from the other seven illustrations, although they obviously utilized some mode of propulsion. Considering the context of the scene and that the artist was capable of representing rowed or paddled propulsion, one suspects that these vessels may have been towed or punted. An iconographic example of puntung was indeed found on a pottery mold in Trier.109

A shift in the number of banks depicted on river warships occurs from the period between circa 250 and 450 (Chart 55). Vessels with only a single bank of oars are shown in a variety of mediums, which results in a sample that is less biased by the work of an individual artist than those from the previous period. Furthermore, the theme of the illustrations is not a single large military-campaign. These ship depictions correspond well with the archaeological material from Mainz, and provide overwhelming evidence for the exclusive use of single-banked river craft in the period.

North Sea vessels

Indigenous-built seagoing vessels from the North Sea region utilized both sail and oared propulsion. Evidence of sail propulsion is found in the archaeological material. The Blackfriars and Guernsey ships had large floors that served as their maststeps located at approximately one-third of the ships' length from the bow, while no indication of oar-usage was observed on either of these ships.110 From the placement of the maststeps and the hull shape, Marsden and McGrail argued that the Blackfriars vessel had either a spritsail, due to the maststep being so far forward, or a square sail.111 Marsden also argued that the shape of the hull indicated it sailed best before the wind, whether rigged with a spritsail or square rig, and drew analogies with the Kyrenia replica for use of a square rig similar to that of the replica that could be placed in the Blackfriars ship's forward-located maststep.112

A mosaic dated to circa 250 from Bad Kreuznach, Germany depicts a vessel with a square sail in what appears to be a marine setting.113 This illustration is often used to support the view that North Sea vessels used square rigs. Bad Kreuznach is over 400 kilometers from the North Sea and more than 600 kilometers from the Adriatic. The depicted ship has a single mast, a forward projection from the top of the

109 Pottery fragment with cast decoration, Rheinisches Landesmuseum, Trier, Ellmers, "Shipping on the Rhine during the Roman Period, the pictorial evidence," fig 9.
110 Marsden, Port of London, pp. 51-53, 61-65, figs. 23, 43, 63, 64; Rule, "The Romano-Celtic ship excavated at St. Peter port, Guernsey," p. 54, fig. 5.7.
111 Marsden, Port of London, pp. 70-74.
112 Ibid.
113 Ellmers, "Shipping on the Rhine during the Roman Period, the pictorial evidence," p. 3, fig. 3.
stern, a volute stern decoration, and is carrying amphoras. This superficial representation of the marine setting could be equally interpreted as the Mediterranean or North Sea, and there is no convincing evidence for either location. That the ship carries a “Celtic leather sail” is not only unlikely, but an overstated and spurious use of the iconographic evidence. This depiction can support the contention that square sails were used in the third century, that the square rig was known in central Europe at this time, and possibly also that artists familiar with Mediterranean ships were working in central Germany.

Mediterranean utility vessels

Small utility vessels depicted from circa 225 to 450 appear to be operating in riverine and coastal waters, and typically look to be fishing boats. Of the twenty-two depictions where details above the hull are discernible, only one is shown with a mast and sail (Charts 60 and 61); the vessel has square sail with brails, shrouds, and braces. There were twenty-three vessels that have the sides of their hulls visible to an extent sufficient to discern if oars were used in propulsion, and of these eleven had a single bank of oars (Chart 60). There is little variation in the total number of oars depicted; eight boats are represented with a single pair of oars and three with a total of four oars. All oars in these illustrations are laid over the top of the sheer strake. Eleven vessels are shown without any sail or oars, although they were probably rowed as well. Historical references to fishing vessels from Late Antiquity correlate well with the iconographic evidence. According to Aelian, fishing with nets required a six-oared boat. However, he also wrote that Herodotus had maintained that twelve oared-vessels were necessary for large nets.

Steering

The foremost mode of steering found in the period under study is the use of quarter rudders. Quarter rudders were large oars that were mounted on the stern quarters of vessels. As quarter rudders were affixed to the outside of hulls, and thus easily lost during wreck formation, they rarely survive in the archaeological record, particularly in underwater deposition. As a result, iconography provides most of the evidence for their occurrence. It appears that these large oars, usually one attached to each stern quarter, were fastened to the ship by a mounting assembly that supported the oars and allowed them to swivel. These mounting assemblies appeared to have consisted of beams, bracing, and ropes placed on the hull’s exterior. A helmsman, who worked the tillers attached to the tops of the oar stocks (or looms), controlled oar movements. For the seventeen illustrations of Mediterranean merchantmen between circa 50 and 250, sixteen had quarter rudders, and eight of fifteen of these show some type of quarter rudder mounting assembly (Chart 50). Similarly, all twenty-one depictions from the period between circa 250 and 450 had quarter rudders, and sixteen of twenty examples had a mounting assembly. Mediterranean warship depictions from these two periods followed the same pattern for the depiction of quarter rudders.

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114 Ibid.
115 In another passage, Aelian also mentioned a small, six-oared ferryboat: *Historical Miscellany*, 12.43, 13.21.
as did the merchantmen. However, mounting assemblies were much less frequently represented for warships (Chart 53). In the two respective periods of illustrations, only one of the twenty-nine examples from 50-250 and four of twenty-four examples from 250-450 were shown with some type of mounting assemblies. Many of these mounting assemblies were obscured by planking along the side of the hull, a feature discussed in the conclusions below.

Depicted river warships were steered in a manner similar the way seagoing warships were steered (Chart 56). All examples of river warships from any period have quarter rudders, and no example showed a mounting assembly. Similarly, seven of the eight depictions of naval transport vessels show quarter rudders without associated mounting assemblies. Despite the scarcity of mounting assemblies in the iconography on river warships, there is possible archaeological evidence for them. Höckmann has argued that a projecting beam at the stern of the Mainz A-7 vessel served as an attachment, or *thramus*, for the loom of the quarter rudders.116 Such a basic configuration may explain the lack of mounting-assembly depictions in the illustrations of river warships, because the profile view of a *thramus* would be quite inconspicuous. An absence of mounting assemblies may thus be a function of river vessel size, in that depictions of other small craft lack quarter-rudder assemblies as well. For example, depictions of fishing vessels from the Mediterranean region have quarter rudders, although only one of the twenty-three also included a mounting assembly depicted (Chart 60). Thus it is likely that smaller craft typically used simple steering oar attachments that did not warrant illustration.

Archaeological evidence has shed some light on steering oars utilized in the North Sea region. A steering oar found in association with the second-century boat from Bruges, Belgium, which measured just over 4.0 meters in length and had a 0.7-meter wide blade.117 A rectangular slot at the top of its stock allowed the tiller to be attached at a right angle. A smaller, but similarly formed, rudder was also found at the fort of Newstead in Britain. Even if these examples were not used as quarter rudders, they are at least our best archaeological representations of how rudders were constructed in the region.

As opposed to an apparent quarter-rudder system, it appears that some Germanic boats from the lower Rhine region and inland areas of Europe opted for a single steering oar mounted over the stern. An oar measuring 5.15-meter in length was found with the vessels at Zwammerdam. The oar bears evidence of attachment at mid-loom and could have been fitted over the sterns of the barges found there.118 Further evidence of a stern oar was found associated with the first/second-century Bevaix boat from Lake Neuchâtel, Switzerland. This oar measured nearly ten-meters in length.119 Ellmers hypothesized that

crews may have made use of both bow and stern steering oars in order to steer the long riverboats. As evidence, he calls attention to the first-century relief of a vessel with a stern and bow oar found near Mainz, Germany.120

*Other Structural Elements*

*Offensive and defensive ship structures*

With only a few military vessels providing archaeological evidence of hull structures, all from fluvial contexts, iconography and literary sources serve as a crucial supplement for seagoing warships. There are many depictions of warships for the period from circa 50 - 250 (Chart 53). Of the thirty-three illustrations that have visible bows, thirty had what appears to be a ram attached to the lower portion of their concave or straight stems. Those warships with convex bows lack these ram-like projections. Defensive screens along the bulwarks are rare in depictions from this period, appearing in only two of thirty-four examples, and soldiers are rarely depicted.

Rams are shown on every warship in the period from circa 250 - 450, except in one instance of a ship that has a convex stem. As in the earlier period, soldiers are rarely depicted on these warships (Chart 53). Although only 6% of earlier vessels have defensive screens, such screens are frequently shown on the warship depictions of this later period. Nearly half the depictions, twelve of the twenty-five examples, from circa 250 - 450 have some type of screen configuration above the sheerwale (Chart 53). Many of these screens appear to be represented as series of diagonally crossing timbers between the caprail and an upper rail (see Iconographic Example 28) or a series of stanchions below a deck (see Iconographic Example 23).121 Interestingly, a few depictions of Mediterranean merchantmen also have a screen, and one of them is shown with a bow projection. Screens did not necessarily have the fore and/or aft break in them noted by Casson for earlier warships and thought to facilitate boarding and debarking.122 Because of their rarity in either period (Chart 53), crenellated bows may have had no military significance, being rather a decorative or artistic addition. There is always the possibility, however, that these were rare depictions of military transports that required increased defensive structures.

In depictions of river warships with a visible stem from the periods between circa 50 - 250 and circa 250 - 450, every stem had a concave or vertical shape with some type of projecting lower portion (Chart 56). Whether these river warship depictions showed vessels with true rams, or simply represented idealized versions of warships operating in river environments, is uncertain. The primary archaeological data for Roman military rivercraft consists of the Oberstimm and Mainz vessels. Unfortunately, these remains consist primarily of lower hull portions, and do not provide significant evidence of offensive and defensive structures. However, the Mainz A-9 vessel does provide some insight into such elements, as it

120 Ellmers, "Shipping on the Rhine during the Roman Period, the pictorial evidence," p. 4, fig. 5.
121 No examples of warships were found dating to the period from circa 450 - 650.
appears to have had a slightly convex or straight stem configuration without a significant forward projection from the keel. This runs contrary to the iconographic evidence discussed above. River vessels would unlikely be fitted with rams for reasons indicated below. However, small cutwaters may have been employed on vessels to increase their speed, or likewise, it is possible that river warships were never constructed with projections. No military transports from 50 - 250 possessed stem projections, and each of their stems was convex in shape. The Mainz Type-B vessel is thought to be a transport craft, and appears to have had a convex stem without a keel projection.

The Mainz A-9 vessel was fitted with mortises placed between tholepins on the top face of its caprail; they probably held small stanchions to support a rail. Höckmann argues that this rail served as an attachment bar for shields that provided protection for the troops on board. Such protection is also in keeping with the iconographic evidence, since a screen is shown in every depiction from circa 50 - 250, and on seven of the eleven of those from circa 250 - 450. Of the eight military transports from circa 50 - 250, none are shown with screens or soldiers on board. Instead, these simplistically depicted vessels carry horses that presumably belonged to cavalry units.

Decking

Evidence of decking is primarily associated with larger seagoing vessels and fishing boats. The shallow-drafted river barges of the lower Rhine region were open craft designed for carrying various cargoes in relatively calm waters. Although Höckmann has reconstructed the Type-B Mainz military vessel with a large deck, there is no direct archaeological evidence presented for the presence of such decking. Decking may have been present on the Fiumicino vessels, but further analysis of these vessels is required.

Archaeological and written evidence suggest that Mediterranean seagoing vessels were all probably decked to some degree. A late-fourth-century literary allusion by the author Libanius, for example, refers to decked merchantmen. Many seagoing vessels from the Mediterranean, and a few from the North Sea, preserve archaeological evidence for decking. Deck beams were found on the Blackfriars, County Hall, Laurons 2, Pantano Longarini, and seventh-century Yassada vessels. Holes for stanchions that likely supported deck structures were also detected on the Pointe de la Luque B and

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124 The archaeological evidence simply is not complete enough to hypothesize beyond a few possible configurations.
125 Höckmann, “Late Roman River Craft from Mainz, Germany,” pp. 31-32.
126 Ibid., pp. 25-29.
127 Ibid., p. 30-31.
Port-Vendres I vessels. The most complete evidence for decking was found on the Laurons 2 vessel, where 4.0-centimeter thick deck planks, averaging 25.0 centimeters in width, were joined with unpegged mortises and tenons. These deck planks were nailed to deck beams that were 9.0 centimeters sided by 15.0 to 18.0 centimeters molded and located at every other frame station. Rider beams that were integrated into the ship’s wales completed the Laurons 2 vessel’s sturdy deck structure, which was cambered over its length. This deck had an opening for a hatch near amidships, and scupper holes were cut into the timbers around the deck’s perimeter to allow for water run off. The County Hall vessel had several deck beams that were slotted into a wale. These beams were approximately 3.8 centimeters thick and up to 5.0 meters in length. Stanchions set into stringers likely supported a longitudinal timber underneath the deck beams.

As depictions of seagoing merchantmen and warships are rendered in profile, it is difficult to ascertain the presence of decking on the vast majority of them. However, a number of merchantmen are shown with what appear to be beams protruding from the sides of the upper hull. Considering the height of the beams within the hull, it is certainly plausible that these were deck beams. Four vessels from circa 50 - 250, and six from circa 250 - 450, had through-beams (Chart 50). From a later period, the seventh-century Yassadi ship also had through-beams, at least in the stern.

Although warship illustrations are not forthcoming in their depiction of decking, there is some historical reference to decked warships. Procopius, for example, mentions the presence of decks on warships that engaged the Vandals in around 470. Decking is clearly evident on portrayals of smaller fishing and pleasure craft. In seventeen fishing boat representations where it was possible to assess the presence of decking, fifteen had partial decking at the bow and stern (Chart 60). The midships area of these fishing craft were likely left open so that the fishermen could stow their catch. Three of these vessels have through beams, again at a level suitable for deck beams. Likewise, decking is evident in six of eight representations of what appear to be small pleasure craft.

Superstructures

As superstructures are, by definition, above the hull, they are seldom represented in the archaeological record. Archaeological evidence from the seventh-century Yassadi vessel, however, indicates that a stern galley with a tiled, gabled roof probably rose above deck-level. Iconographic evidence for Mediterranean merchantmen and warships provides a useful indication of the type and

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132 Marsden, Port of London, pp. 122-123.
133 Bass and van Doorninck, Jr., Yassi Ada, pp. 52-53.
134 Procopius, History of the Wars, 3.6.23.
placement of such structures. Among this evidence, no merchant ship in any period of analysis is depicted with structures in the bow, and only a single example from circa 50 - 250 has structures amidships (Chart 50). In depictions from the periods of circa 50 - 250 and circa 250 - 450, over a third have structures in the stern; however, in the period from circa 450 - 650, depictions lack any superstructures.

Iconographic evidence for seagoing warships in these two periods follows a similar, but more explicit, trend (Chart 53). Neither bow structures, nor midship structures, were seen in any of the examples from the period of circa 50 - 250. Stern structures were more common in this period, however, occurring in twenty-three of thirty-one depictions. In the examples from the period of circa 250 - 450, stern structures appear in only six of twenty-four representations. They are typically vaulted in shape, with an opening forward, and appear to be closed at their after ends. These vaulted structures are usually rendered with a checkered pattern, which possibly represents planking seams or a tiled roof.

Illustrations of warships in river settings also show a proliferation of stern structures in the period of circa 50 - 250; they occur in ten of the eleven examples (Chart 56). As in the case with seagoing warships, the appearance of stern structures on river warships during the period of circa 250 - 450 occurs only twice among eleven examples. A similar pattern occurs in the depiction of structures in the bow, which appear in six of the eleven examples from circa 50 - 250, and which disappear in depictions after circa 250. There are no depictions from either period that have examples of midship structures. Depictions of river transports come solely from circa 50 - 250, which exacerbates the determination of a trend over time. These illustrations have only stern structures, which occur in seven of the eight illustrations (Chart 58).

**Ship Decoration**

Decoration is an important aspect of watercraft, because it was one of the most distinctively cultural-based characteristics they possess. While both the usage demands and available technology strongly influences the construction features of a vessel, decoration has a different set of determinates. These determinates include an individual's adherence to mythological systems, social history, exposure to folklore and rituals, personal taste, and the communication requirements or desires for the watercraft. With almost no decorative data available from archaeological remains for this period of study, the analysis is heavily dependant on iconography and written sources. Since artists producing ship representations were also influenced by a plethora of cultural influences, agendas, and personal tastes, it is impossible to know whether a particular vessel actually possessed some or all of the decorative elements shown, or if the artist added them in order to convey particular messages. Thus, in order to utilize the iconographic data in a meaningful way, it must be assumed that decorations on ship representations were reasonable in that they generally appeared on ships in the area and time period of the work or locale that the representation depicted. Furthermore, by taking a group of iconographic examples as a whole, it is hoped that the vagaries of an individual artist will be overcome.
In this analysis of trends, separate decorative elements were identified and placed into distinct nominal categories in order to determine frequencies (see Appendix B: Iconographic Examples for examples of individual elements). The decorative element in these categories probably represent a conservative sampling of the full variety of ship decorations that were actually used in the Mediterranean during Late Antiquity. Of the imaginative decorative embellishments utilized by thousands of boat owners that found their way into iconography, only a meager number of these probably have survived to the present day. Unfortunately, there is scant archaeological or iconographic evidence for decorations on indigenous-built Germanic or Celtic vessels from the rivers of northern Europe or from the North Sea. Written accounts from this period also lack adequate allusion to ship decorations for these areas. The scarcity of surviving evidence, however, does not indicate that these vessels were not decorated in some manner.

Merchant and utility vessels

Mediterranean merchantmen are often shown with both bow and stern decorations (Chart 51). Bow and stern decorations on ship representations appear to be the actual shapes of, or additions to, the stern and stemposts. In each of the three periods considered for iconographic study, every ship is shown with some type of prow and stern decoration, except for one prow in the period of circa 250 - 450, and three in the period of circa 450 - 650. The most common bow decoration is a slightly flaring flat-shaped terminus that appears in nine of the seventeen depictions from circa 50 - 250 (Chart 51). The second most common decorative elements in this period for bows are a volute and some type of forward projection from the top of the stem. For the stern in this period, a goose head is the most frequently encountered, depicted in eight of the seventeen examples, with all but two of the goose heads accompanied by an extension of the deck off aft of the stempost which will be referred to as a deck projection. Although these bird heads are sometimes classified as swans, the goose is a more probable identification. Geese were long revered birds in Roman society, having saved Rome from a stealth attack by the Celts, in one popular legend, by waking the troops on the citadel. Consequently, a goose was borne on a litter during an annual holiday to celebrate this event. A third of this period's eighteen depictions had banners, usually at the top of the masts, and only one of seventeen visible forequarters had an occlus. In depictions from circa 250 - 450, the flat terminus and volute continued as the predominant decorative bow elements, with the latter increasing in frequency from the earlier period (Chart 51). Both appear in seven of twenty-five examples respectively. Forward projections decrease from the previous

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136 This deck projection has produced numerous hypotheses of both function and decoration, yet without archaeological evidence for its structure or attributes, its exact nature remains uncertain. As such, it will be included in the discussion of decorative elements in order to track its frequency in iconographic depictions. Functional possibilities of such a structure will be explored in the conclusions of the chapter.

137 Aelian, Historical Miscellany, 12.33.

138 The example is found on the left-most ship on a mosaic from the Foro delle Corporazioni, Ostia, dated to circa AD 200; in L. Casson, Ships and Seafaring in Ancient Times, p. 110, fig. 82.
period to around half the frequency, occurring in three of twenty-five examples. Birdheads, other than the goose, make their first appearance on bows in this period, appearing in two of the twenty-five examples. The goose head and deck projection continue to adorn many of the sterns in ship illustrations, but appear less frequently than in the previous period, each present in five of the twenty-two examples. In contrast to the decrease in the goose heads and deck projections, there is a significant increase in the instances of the flat terminus on the stern. Compared to the previous period, this element more than doubles in frequency, as it is found in twelve of twenty-two examples. In four of twenty-two instances, the flat elements were at the end of a projection that curved inboard. Similar to the previous period, seven of the twenty-three depictions had banners, usually shown on the mast. Only one out of twenty-three examples had an oculus depicted on its forequarter (Chart 51).

There was a decrease in the number and complexity of bow decorations in depictions from circa 450 - 650. Five of the eleven depictions have a forward projection, by far the most common decoration, with only a single occurrence each of an animal head and inboard projection (Chart 51). The flat-terminus in the bow drastically decreased by this last period, with only a single occurrence in the examples. There is an apparent decrease in stern decorations as well, with the goose head and deck projection disappearing altogether. In this final period, the volute and flat terminus occurs in three of the eleven examples. Only two of the eleven vessels in this period possess banners, one each on the mast and yard, and none of the vessels is shown with an oculus on its forequarter (Chart 51).

All examples of fishing vessels and pleasure craft had decorative features, and all are dated between circa 225 and 450 (Chart 61). The predominant bow decorations on the twenty-three fishing boat examples were a forward projection, a volute, and a flat-terminus. These elements appeared in six, five, and four of the twenty-three depictions, respectively. One boat has a goose head on the prow, but no other animal head appears on any of the vessels. Most common among the stern decorations are the aphlaston and the flat-terminus. There are a few other unique decorative elements that make an appearance on fishing boats, such as the crescent and ball, as well as a relief (or painting) in one example. A single representation was depicted with a banner on its mast, and one vessel out of twenty-three had an oculus on its forequarter (Chart 61). In depictions of pleasure craft dating between circa 50 and 400, there were a wide variety of prow decorations. These decorative elements include inboard projections, goose heads, volutes, and bird heads. Likewise, stern decorations are quite varied, and include volute, aphlaston, deck projection, inboard projections, and inverted projection elements. Many of these vessels also had geometric patterns depicted along the sides of their hulls.

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139 The lack of oculi shows a clear cultural break with earlier periods. Hence it is difficult to argue for a Greek domination of the shipping industry. Greece in Late Antiquity was a minor province outside of the main socio-economic developments taking place elsewhere. Ravaged by invasions, especially in the fifth and sixth centuries, it was not in a position to dominate any industry or profession. One should not
Military vessels

Bow and stern decorations on illustrations of seagoing warships were very common in the periods of circa 50 - 250 and circa 250 - 450 (Chart 54). All but a single example from each period had a bow decoration, and all but one from circa 50 - 250 displayed stern decorations. The most common prow decorative element from the period between circa 50 - 250 was a forward projection from the top of the stem, found in twenty-two of the thirty-six examples, followed by the volute in eight instances. No other decorative element occurred more frequently than in three of the thirty-six examples. Stern decorations or additions from this period were dominated by three decorative elements: the aphlaston, a deck projection, and an inboard projection. These elements appear in thirteen, twelve, and twelve of the thirty-one examples, respectively. The inward projection and aphlaston elements appear together in 39% of the depictions, and all three of these elements occur together in 21% of the depictions. Few animal representations are present. However, two animal heads, each associated with forward projections, are found among the representations from the first period. The oculus on the forequarter appears only once among the thirty-six examples.

The forward-projection and the stylistic volute continue to be the most common bow decorative elements in the period from circa 250 - 450, although they switch in frequency ranking from the previous period (Chart 54). The volute is present in ten of twenty-five depictions, and the forward-projection decreases slightly to nine depictions. There was a significant change in the use of animal and bird heads as decorative elements. Four animal, one bird, and one goose head appear on a total of six of the twenty-five bow depictions. The frequency of stern decorations declines slightly from the previous period to 75% of the total examples. The aphlaston and deck projection virtually disappear in the stems during this period, although the inboard projections slightly increases, appearing in eleven of twenty-four examples. As with bow decorations, the bird and goose head each appear on a single representation in the stern, and only two of the twenty-five vessels has an oculus on the forequarter.

Warships shown in river settings differ significantly from seagoing warships in the types of decorative elements shown (Chart 57). Overall, river warships appear to be slightly less decorated. In depictions between circa 50 and 250, bow and stern decorations occur in 79% and 82% of the examples, respectively. Two-thirds of the vessels in this period had a relief scene at the bow, while no other decorative element occurs in more than two of the nine examples. Stern decorations in this period are dominated by the aphlaston, in seven of the eleven depictions, and the deck projection, in eight of eleven depictions, but no inboard projections were depicted. Six of the eleven ships possess a goose head in the stern, and one example had another type of zoomorphic head. Compared with warships in this period, military transports are lacking in decoration. Only one of the four visible examples have a decorated prow

confuse the use of Greek language in the East with the influence of regions that may have had importance centuries earlier, such as Achaea and the Peloponnesus.
and inboard curve, and of eight discernable sterns, each possesses only a flat-terminus design. Two of the nine river warship representations show oculi on their forequarters, but this element is absent among the depictions of military transports.

Each river warship depiction from between circa 250 - 450 has some type of bow decoration, and 64% had decorations in the stem (Chart 57). In lieu of relief scenes found in the previous period, four of the eleven depictions in this period have a goose head in the bow and three had other zoomorphic heads. Also in the bow in this period, a forward-projection with a flat terminus decorative element debuts, found in three of the eleven vessels. In the stem, the total number of vessels depicted with an aphlaston fell to three of eleven examples, and the deck projection disappear altogether. These elements are replaced by stylized zoomorphic designs. Zoomorphic heads are the most common decorative element in the stern, found in five of the eleven examples. Three of the heads are not identifiable, one is of an unidentified bird, and one is a goose head.

Standards were often placed in the sterns of riverine or seagoing warships to designate the vessel of the commander and/or unit. During the period between circa 50 and 250, seven of twenty-nine seagoing warship depictions have standards shown in their sterns; these always appear in pairs (Chart 54). Only two of the eleven river warships in this same period had standards (Chart 57); one of these has a single standard and the other is fitted with three standards in the stem. A single vessel has what appears to be a standard in the bow, although it is difficult to identify it with certainty (Chart 54). By the period of circa 250 - 450, standards are absent from river or seagoing warship depictions, although historical references suggest that they were present at this time. Valentinian, in crossing the Rhine to meet with Macrianus in 374, boarded riverboats staffed with officers and decorated with standards. Maurice also advocated that each warship have a standard on its masthead in order to indicate the officer in command.

Summary and Conclusions

Mediterranean merchantmen

There was very little variation in the length-to-beam coefficients of merchantmen during Late Antiquity. It appears that conventions in shipbuilding had been developed centuries earlier that established the ideal trade-off in space for speed, this being a coefficient value of approximately 3.0. McGrail has offered a categorization of sailing vessels based on their length-to-beam coefficients, where a value of less than or equal to 2.6 denotes a beamy ship, a value between 2.6 and 3.8 denotes an "average" ship, and a value of greater than or equal to 3.8 indicates a narrow ship. For the thirteen archaeological examples in this period with good estimated dimensions, two were beamy, ten average, and one narrow.

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140 Ammianus Marcellinus, *The Later Roman Empire*, 30.3.4-5.
under McGrail's system (Chart 3). The actual average length-to-beam coefficient of the thirteen ships was 3.1, with a standard deviation of 0.5. This results in a one standard deviation range of 2.6 – 3.6. Using these figures for forming similar categories suggested by McGrail, less than or equal to 2.6 denotes a beamy ship, between 2.6 and 3.6 indicates an average vessel, and greater than or equal to 3.6 denotes a narrow vessel. A similar result is achieved by using this statistical breakdown of the archaeological examples, with two ships being beamy, nine average, and two narrow. A length-to-beam coefficient of 3:1 allows sufficient speed of vessels under sail, while providing a large hold for profitable journeys. Hulls with high length-to-beam coefficients but having the same beam required more wood in their construction compared to those with lower coefficients, although relatively less hold space is obtained. Theoretically, vessels with higher length-to-beam coefficients would be faster, and could potentially make more trading voyages on short routes during a single sailing season. This factor could hypothetically offset some of the diminished hold space. However, given that wind speeds were generally consistent on a given route over time, it was assuredly discovered early on that an increase in speed sufficient to offset an additional cargo capacity that was less cost effective could not be obtained through altering length-to-beam coefficients alone. Greater economic gain was to be realized through the maximization of hold space.

There appears to be a decline in the number merchantmen built on a large scale (thirty meters or more in length) during Late Antiquity. This reduction in vessel size appears to begin sometime in the fourth century (Chart 1). Given an equivalent length-to-beam coefficient and wind speed, a smaller, lighter vessel will travel more swiftly than a larger, heavier one; however, this speed difference is less significant when comparing vessels whose lengths are within ten meters of one another. Furthermore, increased vessel speed was advantageous only for short routes, and not longer ones such as the Alexandria – Rome route. Thus, it is unlikely that an attempt to gain speed was the primary motivation for the decrease in the size of merchantmen over the period under study. Smaller merchantmen, those from fifteen to twenty meters in length, were built millennia before Late Antiquity, and any significant economic benefit from a small increase in speed would have been realized much earlier. Conversely, a larger vessel could carry more cargo at relatively the same speed as a small one and prove more profitable in consideration of economies of scale given that the risk associated with a voyage was kept to an acceptable level for lading large cargoes in a single vessel. Hence, the explanation for the downsizing of merchantmen must be sought among the political and economic events of the third-fourth through seventh centuries.

Cargo capacity is influenced not only by the length-to-beam coefficient, but also by cross-sectional shape of a hull. For a given beam, a box-like hull section provides more internal area than a hull section of semi-circular shape, and thus vessels more closely approximating a box shape would be more

143 It must be noted that these are based on the length and beam estimates given by the excavators; some possibly with the 3.0 coefficient in mind when estimating (Chart 3).
efficient cargo carriers. Also, a hull with a box-like section, built with a robust spine (keel and endposts), sturdy transverse timbers (frames and beams), and secure upper members (deck beams and decks), provides an excellent configuration for handling stresses along the beam.\(^{144}\) Thus, in general, the more box-like a ship was in cross-section, the greater the hold space attainable. However, factors such as size and the amount of wood required to construct a particular hull shape are often ignored when comparing hull shapes.

An examination of the most extreme cross-sectional hull shapes, the rectangle and semi-circle, provide some interesting insights (Chart 62).\(^{145}\) The greatest amount of potential cargo capacity area for box-shaped hulls, as compared to rounded hulls, increases exponentially with the increased size of a vessel. Although, the amount of wood necessary to form the box-shape (circumference) increases by only a slightly greater amount compared to that of the rounded hull shape, even considering for possible additional stiffening. In an attempt to compare the hold capacities for each shape, I will compare the area of a section for each hull configuration. For example, a twenty-one meter by seven meter vessel with a box-shaped cross-section would have around twenty-five square meters of area at midships, compared to circa twenty square meters for a hull with a rounded cross-sectional shape. Likewise, the box-shaped hull would have around fourteen meters of circumference at midships, compared to almost eleven meters of a hull with a rounded cross-section. Increasing the vessel size to thirty meters by ten meters, the box-shape section has nearly fifty square meters of area amidships, with twenty meters of circumference. This is compared to the nearly forty square meters of area, and almost sixteen meters of circumference, for rounded hull shape amidships. Thus, there was a greater increase in cross-sectional hold area as ship size increased, and a better coefficient of circumference to cross-sectional area, for the box-shaped hull. In terms of ship construction, although more timber would be required to form a box-shaped hull, the cost was offset by a significant increase in hold area. Thus the increased capital investment (wood to form shape) would be more than compensated by the increased potential for variable income (cargo area) through transporting greater amounts of cargo per voyage.

Another idea to consider is how large a vessel would have to be in order to provide a given amount of cargo capacity. Again for this analysis, the amount of cross-sectional area amidships will be used as an estimator.\(^{146}\) This is only an approximation, but serves to illustrate the general benefits when comparing the two cross-sectional shapes of hulls. To obtain about twenty-five square meters of cross-


\(^{145}\) Throughout this analysis the relative proportions of height (height = \(\frac{1}{2}\) beam) are used for both shapes. The formulas applied were adjusted basic geometric determinants for circumference (rectangle = \(2\) (height + beam); semi-circle = \(2\pi r/2\)) and area (rectangle = height \(\times\) beam; semi-circle = \(\pi r^2/2\)). Vessels were also considered to have 3.0 length-to-beam coefficients.

\(^{146}\) This is done with the understanding that the cross-sectional area is an indicator of three-dimensional hold space.
sectional area amidships, a box-shaped vessel of approximately twenty-one meters long by seven meters wide would be required, while a twenty-four meter by eight-meter vessel would be needed if the cross-sectional shape of the hull is rounded. Interestingly, the difference in circumference is very small for each respective cross-section, approximately fourteen meters for the box-like hull shape, and twelve meters for the rounded hull shape. If the beams of the midship sections corresponded to the maximum beams of these hypothetical vessels, the box-like ship with its circumference similar to that of the rounded ship at its maximum beam, was nearly three meters shorter than the vessel with the round-shaped hull. Therefore the around the same amount, or possibly less, timber for planking would be required for the box-shaped hull in order to provide a comparable amount of hold space because smaller box-shaped vessels could carry as much cargo as larger more rounded-vessels. Although ships were not constructed with perfectly box-shaped or rounded hulls, the idealized shapes in this analysis approximate what actual hull shapes would have offered as hold space.

Up to the fourth century, the cross-sectional shape of most vessels was more rounded, forming a tubby hull. In the fourth century, hull bottoms became more flat, often with low angles of deadrise from the keel towards the turn of the bilge, which were used to define the shapes of vessels. However, regardless of the angle of deadrise, the sharper turn of the bilges resulted in more box-shaped hulls. A projecting keel, along with the strakes forming a ‘V’-shaped section amidships, could be an additional feature for either box-shaped or rounded hulls. However, such ‘V’ sections are more pronounced in the box-shaped hulls. A box-shaped hull formed by sharper bilges was an attempt to increase hold space, and the pronounced projecting keel provided increased lateral resistance (Figure 3). Hulls with box-section shapes, with flatter bottoms and harder bilges, were already being constructed in the North Sea by the second century. Although there were somewhat different demands on vessels of the two regions, Mediterranean vessels were two or three centuries later in the development of a similar design.

A majority of merchantmen had convex bow and sterns formed by upward curving stems and sternposts. For example, the stem and sternpost on the Laurons 2 vessel were curved to form a convex profile. Similarly, the seventh-century Yassıada ship had a convex sternpost and possibly a convex stem as well. Iconographic evidence suggests that posts were becoming somewhat straighter over the period of study, although this change cannot be supported by the archaeological evidence due to the paucity of examples. A few concave bows were also shown in Late-Imperial depictions of merchantmen. If merchantmen were in fact constructed with such bow shapes, it may possibly represent a design for

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147 For example the Blackfriars vessel: Marsden, Port of London, figs. 56, 58.
148 Both areas produced required that vessels reach into shallow estuarine and riverine waters, as well as cross open bodies of deep water.
150 Bass and van Doorninck, Jr., Yassi Ada, pp. 65-68, figs. 4-4, 4-17, 4-8, 4-9, Construction Plan. With the forward third of the vessel not preserved, it is difficult to ascertain if the stem was convex in shape. However, it was reconstructed with this configuration.
improved entry and speed similar to that in warship design. Projections shown at the water line of merchantmen with concave stems were presumably cutwaters. A finer entry created from a concave stem would have slightly increased speed under sail, but the associated hull configuration would have decreased hold space. These concave-cutwater elements on merchantmen disappeared in iconography by the end of the third century. Apparently designs that favored the maximization of hold space over minimal gains in vessel speed under sail prevailed. It is also possible that these concave-bowed vessels were some type of military transports, or other government sponsored vessels, which placed more of a premium on speed, especially if they were also rowed, and had a limited tenure under the Empire. Scarfing between the stem, stempost, and the keel was relatively consistent over the period, with a similar type of hook scarf utilized in vessels from all regions of the Mediterranean.

Planking thickness declined gradually from the second through fifth centuries, after which there was a more drastic decline through the seventh century. By the sixth century, planking thickness attained dimensions used throughout the medieval period. Thinner planks were used for all size ships, consequently they provided less support and strength for the hull, but also resulted in less overall hull weight. The thinning of hull planking is an important aspect of the construction of hulls with more box-shaped cross-sections. Because a greater amount of wood was necessary to form the more box-like shapes of vessels later in the period of study, compared to the earlier rounded shapes, the thinner planks offset the requirement for additional timber. Additionally, as box-shaped vessels could be smaller in overall dimensions and still provide the same amount of hold space compared to the earlier rounded hulls, thus, over the period, the total amount of planking timber required to construct a vessel with a given amount of cargo capacity was reduced.

In association with the diminished structural role provided by the hull planking, mortises and tenons also diminished in size during the period under study. Mortises and tenons each began reducing in size during the second century, and tenons became suddenly and drastically smaller than their mortises during the fourth century. Hence, tenons no longer filled their associated mortises despite the decrease in mortise sizes. Although both mortises and tenons continued to decreased in their absolute sizes into the seventh century, the difference in relative tenon and mortise sizes within a given ship was greatest in the fourth century, when they initially diverged in relative size; these relative differences in size steadily decreased into the seventh century. The minimum effective size of tenons appears to have been attained by the sixth century.

Consequently, mortise-and-tenon joints drastically lessened in the degree to which they provided structural strength to the hull. Large tenons, typically made from hardwoods and fitting snugly in their mortises, served to increase hull stiffness by acting as numerous internal frames. The size difference between mortise widths and tenon widths no longer resisted movement along the longitudinal axis (incurred through hogging and sagging forces, as well as tortional forces); however, tenon thickness
continued to match the thickness of the mortise cut and thus resisted the transverse movement of hull strakes (shearing forces). Mortises did not always line up perfectly to their counterparts on abutting planks,\textsuperscript{151} for example, in the Dor D remains there were many mortises that were somewhat misaligned, but overlapped one another.\textsuperscript{152} One benefit from utilizing oversized mortise widths was that it allowed less precise measuring and cutting by the shipwright, as only some overlap was required to fit the smaller tenons into both of their mortises. Overlapping would also have somewhat reduced the play that the tenons had in regards to longitudinal movement from hogging and/or sagging forces. Overall, smaller, fewer, and less exacting mortise-and-tenon joints resulted in less labor time, materials, and costs for shipwrights.

In addition to mortises and tenons undergoing fundamental changes in their absolute and relative dimensions over the period under study, the pegs that secured these joints were becoming obsolete. Pegs began to fall out of use probably in the fifth century, and by the sixth century, mortise-and-tenon joints between strakes were unpegged and thus did not provide added strength. A lack of pegs in these joints made them incapable of providing hull integrity. Pegs primarily served to prevent the separation of planks from one another, as opposed to preventing shifting along either the longitudinal or transverse axes, which added to the overall strength of the hull. Only the tightness of fit of tenons in their mortises would prevent the longitudinal shifting of the strakes. Without pegs, only the attachment of strakes to frames served to prevent abutted planks from separating. Tenon length was relatively unimportant in preventing any direction of movement of planks relative to one another. If joints were pegged, the planks would have been prevented from separating, regardless of the tenon length; while if unpegged, the joints would not have prevented separation, regardless of tenon length. However, sufficient tenon length is a factor if they were intended to fill their mortises, and were of sufficient size, to contribute to the structural strength of the vessel. Hence, the looseness of the tenons in their mortises, the lack of pegs, and their wide spacing in areas of hulls indicate that these smaller joints were used primarily for alignment and support of planks until they could be secured to frames. Frame-plank fasteners passing through small and loose joints, as in the seventh-century Yassiada and Dor D vessels, demonstrate that although joints preceded the driving of the frame fasteners, care was not taken to maintain the integrity of tenons.\textsuperscript{153}

By the end of the period under study, with mortise-and-tenon joints playing less of a role in providing hull strength and more reliance being placed on the internal members, some planks were, consequently, attached to at least a few pre-erected frames. Hence, by the end of Late Antiquity, the entire outer hull of many vessels built in the Mediterranean would not have been completed before frames were

\textsuperscript{151} One factor in the degree of misalignment is that planks are often recorded while lying flat on the seabed, while in their original configuration misalignment often decreases.


inserted, as had been the usual practice during the Late Empire. Fastening evidence suggests that after a number of bottom strakes were placed, some frames were inserted and planks were subsequently attached to them. For example, Steffy theorizes that after the first five or six strakes were positioned with aligning mortise-and-tenon joints in the seventh-century Yassiada ship’s hull, some floors were then added that extended a small distance beyond the planking. Next, the planking to the turn of the bilge was erected followed by the insertion of frames that extended a sizeable distance beyond the bilge turn. Planking then continued to the waterline strake, after which there were no mortise-and-tenon joints found in the planking. This indicates that the half frames were pre-erected for the attachment of planks and wales above this point. Evidence for the small Tantura A ship, dated to circa 500, indicates that at least most of, if not all, the frames were erected before planks were attached. This evidence included the lack of mortise-and-tenon joints, caulked planking seams, the use of butt scarfs in the strakes, a lack of temporary form attachments, and the scarffing of floors to futtocks.

The primary plank-to-frame fasteners in the period were nails and/or treenails. There does seem to be a preference for the type of fastening over time, although not over geographical region. A combination of methods can be found on many vessels, however, one of the types acted as the primary fastening method throughout the vessel. For example, fastening evidence from the Dor D vessel indicates that nails were likely used for temporary fastening at a few frame stations until treenails could be inserted at each frame to permanently secure the strakes in place. During the fifth century, there was a change from treenails acting as the primary plank-to-frame attachment to that of iron nails (Chart 63). The preference by the shipwright for treenails as opposed to nails on the Dor D vessel is an exception to this general trend toward using nails as the primary fastening method over Late Antiquity, although it does not discount the general trend towards the favoring of iron nails as the primary fastening method.

The main longitudinal timbers in Mediterranean merchantmen also experienced changes during the period under study. Beginning in the fourth century, keels became larger in cross-sectional area and had increasing aspect coefficients, regardless of overall vessel size. Both these keel characteristics provided increased resistance to hogging and sagging. These trends in keel dimensions were particularly important, as it served to offset some of the loss in longitudinal strength due to the utilization of thinner planking. The highest keel aspect coefficients were associated with seagoing rather than river craft, presumably because seagoing vessels were exposed to greater hogging and sagging forces, and a further projecting keel improved lateral resistance during sailing. Although there are fewer examples, endposts followed a similar trend. The overall cross-sectional area of other longitudinal support timbers, such as proto-keelsons and central stringers, also began to greatly increase by the fifth century. These timbers

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154 Bass and van Doorninck, Jr., Yassi Ada, pp. 70-79.
were progressively augmented to a greater extent by the use of attached stringers, wales, and ceiling that were fastened in place. Maststeps from any period were typically secured to other timbers in order to spread out the forces exerted from the mast, and needed to be robust timbers as they absorbed much of the rearward, lateral, and downward forces from the wind.\textsuperscript{157} Hence, for the vessels of the period under study, by sitting maststeps atop the frames and central stingers, the downward forces from the mast were distributed through more of the larger timbers in hulls.

There may have been a regional preference for certain types of longitudinal support. Western Mediterranean shipwrights possibly had a proclivity for the use of central stringers with connecting chocks, whereas those in the eastern Mediterranean may have primarily relied on proto-keelson timbers.\textsuperscript{158} Four vessels incorporated central stringers, all with western Mediterranean connections. The Laurons 2 ship was carrying amphoras from North Africa, and the Port-Vendres 1 ship contained a similar cargo from North Africa and Lusitania.\textsuperscript{159} The Bourse de Marseilles ship was a small coaster, probably engaged in cabotage along the southern coast of Gaul,\textsuperscript{160} while the Pantano Longarini vessel was found in Sicily and was most likely built of timber from Italy.\textsuperscript{161} Of the four vessels with proto-keelson timbers, both of the Yassada vessels were transporting amphoras with eastern origins,\textsuperscript{162} and the Pointe de la Luque B ship had both eastern and western amphoras.\textsuperscript{163} The origin of the cargo found in the Monaco ship remains uncertain.\textsuperscript{164} The Anse St. Gervais 2 ship had both central stringers and a proto-keelson timber, and was carrying wheat that was possibly from Africa, or was engaged in their local distribution after arriving in Gaul from North Africa.\textsuperscript{165} Admittedly, cargo origins do not equate with ship origins and there are other difficulties associated with determining the origin of a ship, but the pattern may be present and warrants further investigation.

Transverse timbers were also increasing in overall size during this period, but to a lesser degree.

\textsuperscript{157} The forces on the maststep varied with wind direction but were present in more than one direction; where a following wind from off the water may create more rearward force, wind from off stern would cause increased lateral forces and wind from a higher angle could cause more downward forces. The setting of the sail also played a role in the direction of forces on the maststep, as well as its intensity. For example a sail left to billow to a great extent could cause lift on the mast and reduce much of the force on the maststep; hence the necessity for adequate shrouds and stays.

\textsuperscript{158} Additional data is required to substantiate this hypothesis, for not only is determining a ship's origin is often problematical, it is nearly impossible to determine a ship's origins based only on its cargo.


\textsuperscript{160} Gassend, Lacidon, pp. 4-10.


\textsuperscript{163} Parker, Ancient Shipwrecks, p. 247.

\textsuperscript{164} Parker, Ancient Shipwrecks, pp. 279-280.

\textsuperscript{165} Jezgou, "L'épave II de l'anse Saint-Gervais à Fos-sur-Mer (Bouches du Rhône): Une navire du haut Moyen-Âge construit sur squelette," pp. 139-146; Parker, Ancient Shipwrecks, pp. 372-373.
than the longitudinal timbers. Although frames were getting slightly larger from the second to fourth century, their spacing remained relatively constant in all vessel sizes. After the fourth century, frame dimensions remained relatively constant in relation to vessel size through the seventh century. There was not a trend towards a greater number of frames in vessels of similar sizes during the period under study, as the number of frames per unit-length-of-vessel essentially remained constant from the second through seventh centuries, apart from a possible brief increase during the fourth century (Chart 28). A portion of this increase is associated with the data from the Laurons 2 vessel, probably a merchantman that was specifically designed as a grain carrier and somewhat overbuilt. Although frames did not become drastically larger nor increase in number, it is evident that shipwrights were aware of the support that frames could potentially offer, since frames were increasingly integrated into the hull through attachment to the keel. There was an increased percentage of frames that were attached to the keel on ships beginning around the fifth century. Prior to the fifth century, approximately fifteen percent of frames were attached to the keel, whereas after the fifth century nearly twenty-five percent were attached. Transverse support was supplemented by full decking on merchantmen, a feature found on vessels throughout the period. Decking served to protect cargoes, and provide space for working the rigging, sleeping (either in open or, on larger ships, within cabin quarters), and stowage areas for gear and supplies. There is not adequately available evidence to determine if deck beams were increasing in size and in their integration, as was the case with frames.

Collectively, these trends in hull construction and timber scantlings indicate a fundamental transition in the way hull strength was achieved; strength derived primarily from thick hull strakes towards combining internal timbers and wales with thinner planking. As planking became thinner and tenons no longer functioned as stiffeners, longitudinal and transverse support timbers increased in their size and especially in their integration with the hull. At the same time, the sequence of construction was shifting from securing frames to a pre-erected shell of hull planking to the installation of some frames before the construction of the hull planking was begun. The majority of these major transitions took place or had their most drastic changes during the fourth and fifth centuries.

Second-century merchantmen had relatively thick planking compared to those of later vessels, and also utilized large, closely spaced mortise-and-tenon joints to join the strakes. The tenons in these joints completely filled their mortises and were secured with pegs. The largest ships constructed were frequently reaching lengths of thirty or more meters, and the shapes of hulls amidships were rounded in cross-section. From this point, construction elements began to simultaneously change at different rates.

Chart 74 places many of these construction trends together over the time period under study for relative comparison. Planking thickness appears to have decreased gradually from the second to fifth centuries, then began to more drastically decline. Mortise-and-tenon joints rapidly decreased in size in the third/fourth centuries, with tenons precipitously reduced in size, so that they no longer filled their mortises.
By the fifth/sixth century, tenons had reached dimensions roughly maintained thereafter throughout Late Antiquity. Simultaneous with this decline in planking thickness, and in mortise and tenon dimensions, there was an increase in the robustness of keels, proto-keelsons, and stringers. Additionally, frames were slightly increasing in size from the second to fourth centuries and more of them were being attached to keels after the fifth century. In the fourth century, contemporaneous with the drastic change in mortise-and-tenon joint dimensions, there was a possible increase in the average number of frames per unit length of vessel, which by the fifth century fell to quantities of earlier centuries. In general, by the fourth century, large seagoing merchantmen were no longer built as frequently as in the second and third centuries. Furthermore, cross-sectional shapes of hulls, especially amidships, were becoming much more box shaped. Possibly as early as the fifth century, some frames were placed in the hull before all the planking was installed, and definitely were by the sixth century in smaller vessels. By the sixth/seventh century, pegs virtually disappeared in mortise-and-tenon joints, longitudinal timbers continued to increase in size, planking continued to become thinner, a higher percentage of frames were attached to the keel, and frames were placed in the hull before planking was completed in larger vessels. The drastic reduction in planking thickness, especially later in the period, more than offset the increase in the dimensions of other timbers, and ships were becoming generally lighter at the end of Late Antiquity. These lighter vessels of the sixth and seventh centuries had greater available hold space than similarly sized vessels of the second and third centuries.

No single factor can completely account for these adaptations, although some idea of the design factors driving these trends may be ascertained through an examination of the differences between hulls at the beginning and at the end of the period under study. Several basic differences are observed in the designs of merchantmen of the Late Empire and those constructed at the end of Late Antiquity. Later vessels had increased hold space, less wood used in their construction, reduced hull weight for like-tonnage vessels, and fewer labor-intensive components. In order to increase the amount of hold space without increasing the length, beam, or height of the hull, its cross-sectional shape was modified. While a pure box shape in hull section was not structurally sound or conducive to optimal sailing, a more boxy shape than possessed by the earlier rounded hulls was preferred. However, the transition was not achieved by a simple matter of design modifications; rather, some fundamentally new construction principles had to be adapted so as to achieve the design modifications.

To achieve the new hull shape, strakes were required to turn more sharply inward towards the posts, and they had to be bent over sharper bilges. Consequently, a problem that would have faced second-century shipwrights in forming hull shapes of the seventh century is the difficulty in bending thick strakes around the harder bilges and tighter turns towards the posts. This problem would have been amplified for smaller vessels of fifteen to twenty meters in length, which had less length to facilitate the strake bends than did larger vessels. Thinner planks were required to accommodate the curvatures of the
desired designs. However, thinner planks were not suitable for the large mortise-and-tenon joints of second- and third-century hulls, nor could they play their crucial role in providing hull strength. The development of stronger and more integrated internal timbers facilitated the reduction in planking thickness and help to offset the loss of large mortise-and-tenon joints that provided internal stiffening.

One of the most significant developments was the reduction in total ship weight for like-sized merchantmen over the period under study. A ship’s hull and deck planking taken as a unit is a very large component of the total ship weight, thus reductions in planking weight had significant repercussions for the vessel as a whole. Although the increase of other internal timbers offsets some of this reduction, there were probably significant reductions in the overall weight of typical vessels. As an illustration of this point, the total estimated weight of the seventh-century Yassada vessel is compared with a hypothetical Yassada-type vessel built in the dimensions of the Bourse de Marseilles ship dated to circa 200 (Chart 64). 164 Chart 65 shows the different estimated tonnages of principle hull timbers in both vessels, as well as estimates of other contributors to total ship weight. There is a significant amount of weight reduction in the hull and deck planking, from the earlier to the later vessel, from about twelve to six metric tons. This reduction, however, is partially offset by the heavier keel, frames, stringers, ceiling, and clamps of the later vessel. The employment of heavier support timbers higher in the hull in the later vessel also offsets some of the shift in weight distribution in the later vessel from above to below the load waterline. The resulting estimate for the total weight of the earlier vessel is about 22.5 metric tons, and for the later one about 20.3 metric tons, a difference of almost 2.2 metric tons. Steffy has estimated that the displacement (maximum, fully laden tonnage) for the Yassada vessel was about 72.9 metric tons. 167 Thus, using these timber weight estimates, the Yassada vessel had an approximate cargo capacity of about 52.6 metric tons. If we assign to the early vessel the same displacement as that of the Yassada vessel, it would have had a cargo capacity of about 50.4 metric tons (Chart 66). The difference of around 2.2 metric ton represents an almost five percent increase in the Yassada ship’s cargo capacity. On the surface, a five percent reduction in overall weight may seem somewhat insignificant. However, in the large scale in which the shipwrights were working, a 2.2 metric ton difference in building materials is quite significant. The reduction in materials used and the ability to construct lighter vessels, are two of a number of fundamental factors underlying the changes in ship construction over Late Antiquity.

A primary consideration associated with constructing lighter vessels was the greater cargo capacity it allowed. An increase in the amount of cargo translated into an increase in potential profits per trading venture. For example, using an average figure of 46.6 kilograms for the weight of a full, large

164 Where there was a lack of evidence for structures, they were hypothetically reconfigured equally for both vessels in order to reduce bias. For example, without deck evidence, an estimate of 75 square meters of decking was used for both vessels.

167 Bass and van Doorninck, Jr., Yassi Ada, pp. 85-86.
Type 2 amphora carried on the seventh-century Yassada vessel, a 2.2 metric ton reduction in cargo capacity for the earlier vessel would represent around forty-seven fewer amphoras that could have been carried. This equates to a loss in cargo of around 1,701 liters of wine per trip. In terms of monetary revenue, carrying this extra amount of wine would have earned between 15.5 solidii per leg of a trading voyage in the mid-fifth century. As a measure of the solidius' purchasing power, one solidius would have supplied a soldier's rations for an entire year in Numidia or Mauretania in the mid-fifth century. To gain a perspective of operating a merchantmen over a year's time, completing twenty such trading ventures would have generated a tremendous revenue increase of approximately 300 solidii.

The estimates of additional cargo capacity above are based only on the weight differentials between the two vessels at the beginning and end of the period under study. Another important consideration was the shape of the hold. The more box-shaped hull sections in the later periods provided more cargo space. Thus, the changes of hull shape, shifts in timber component dimensions, increases in the integration of hull timbers, and the decrease in total wood weight were changes that occurred in conjunction with one another as a simultaneous trend and not as separate developments.

Another perspective from which to view the cost benefits of building lighter vessels is the size of a vessel required for given cargo amounts to be carried. This would have been an important consideration in many ship construction ventures when planning the cost and size of merchantmen based on the cargo demands envisioned by the operators. As outlined above, the seventh-century Yassada vessel was approximately 20.0 to 21.0 meters in length and around 5.3 meters in beam, resulting in a 4.0 length-to-beam coefficient. This vessel had a keel length of 12.0 meters and a more box-like cross-sectional shape at midships than that exhibited in earlier vessels. The estimated total displacement of the seventh-century Yassada vessel given by Steffy is 72.9 metric tons. Using an estimated total ship weight of 20.3 metric tons (Chart 64 - 66), the estimated cargo capacity of this vessel is 52.6 metric tons. This tonnage figure is consistent with the 50-metric-ton burden estimate by van Doorminck through calculation of the weight of amphoras carried on board and their potential number in a fully laden hold. These figures are for displacement at the estimated water line, and it is noted by Steffy that the seventh-century Yassada vessel could have carried slightly more cargo, possibly up to 60.0 metric tons, if descent weather conditions were expected. Using the same length estimate and the same maximum displacement of 72.9 of the Yassada vessel for the Bourse de Marsailles vessel of circa AD 200 and then calculating this ship's hull weight with associated gear (an estimated 22.5 metric tons), we derive an estimated cargo capacity for an average 21.0-meter vessel in the second to third century of 50.4 metric tons. Allowing for some

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168 ibid., p. 163.
169 200 sextarii of wine per solidius; 4 solidii per year per soldier. Codex Theodosianus.
170 Bass and van Doorminck, Jr., Yassi Ada, p. 312. This vessel had a slightly higher length-to-beam coefficient than many others from Late Antiquity.
171 Bass and van Doorminck, Yassada, pp. 86 and 163.
additional capacity above the water line, we estimate that such a vessel might have had a cargo capacity potential of around 54 metric tons.\textsuperscript{172}

A rough estimate of ship lengths meeting Scaevola's tonnage figures for imperially commissioned vessels were 65 and 325 tons would be approximately 24-25 and 33-35 meters respectively. These vessel sizes correspond well with the range of ship lengths found in the archaeological record dated to the third century (Chart 2). However, merchantmen from later periods may have also been in the 21-22 and 28-30 meter ranges to meet these same requirements. Archaeological evidence indicates that vessels by the end of Late Antiquity were typically around 18 to 22 meters in length. Thus, less capital investment for materials and labor was required to build a merchantman in the seventh century compared to the second century for transporting a similarly foreseen amount of cargo tonnage. Moreover, a reduction in ship sizes did not necessarily translate into a concomitant reduction in tonnage capacity over the period. As will be discussed in the following chapter, a parallel increase in amphora efficiency with that of hull efficiency would have further offset the loss in cargo tonnage capacity associated with reduction in ship size.

The dimensional trends of timbers delineated in this chapter were intrinsically connected to the construction sequence of vessels. The decrease in planking thickness resulted in the abandonment of mortise-and-tenon joints. Therefore, changes in construction had to offset the reduction in planking thickness and reliance on mortise-and-tenon joints by increasing the robustness of internal support and the reduction in the effectiveness of mortise-and-tenon joints to hold strakes in place by affixing frames to planking earlier in the construction sequence. Moreover, having some frames inserted before the hull planking was fully completed allowed for an increased control over hull shape that then simplified the construction sequence.

In addition to having lighter but still strong hulls that could carry more cargo due to their designs than could earlier vessels, these new ships also realized some sailing benefits. Typically, the total cargo had a slightly lower center of gravity than the hull timbers as a unit, because the former was concentrated in the lower portions of the hull. Thus, holding other factors constant, lighter vessels able to carry more cargo would have increased stability due to a lower center of gravity. As a result, shipwrights would have had additional flexibility in the construction of deck structures or other components that added weight higher in vessels. The stern structures depicted on many merchantmen throughout the period (Chart 50) probably represented a galley superstructure similar to the one found on seventh-century Yassada ship. Additionally, the more box-like hull sections with harder bilge turns and the larger keels with higher aspect coefficients provided a hull with as adequate a lateral resistance when under sail as was the case for rounder hulls. Although a rounded hulls of similar size to that of a box-like one typically has a deeper

\textsuperscript{172} Although I hesitate to allow an additional 13% to the potential cargo capacity as with the Yassada estimates by Steffy (Bass and van Doorninck, \textit{Yassada}, p. 86), an additional 7% may safely be proffered
draft, the lateral resistance of the vertical sides associated with box-like hulls compensated for their shallower draft. Increased stability and an adequate lateral resistance allowed vessels to sail better with winds off the stern; both important in the utilization of the lateen sail that became more prolific towards the end of Late Antiquity.

Rigging of Mediterranean merchantmen was consistent in iconographic depictions, with vessels having brailed square sails attached below a single yard. Illustrations of rigging also support the apparent reduction in the number of large ships operating from the mid third century onwards. A shift from two- and three-masted vessel depictions to single-masted ships is quite clear, and is consistent with the archaeological evidence of decreasing ship size. Vessels requiring two masts were possibly associated with the upper size range of early vessels, this being around thirty plus meters in length. The second sail was virtually always an artemon on these larger ships, and it was presumably unnecessary on smaller vessels, hence, its decline in depictions after circa 250.

Merchantmen were consistently outfitted with two quarter rudders affixed to the outside of the hull in the stern by means of a mounting assembly. As quarter rudders were heavy, these mounting assemblies served to support the weight of the oar and provided a pivot point for their rotation. Casson notes the presence of ‘outriggers’ or ‘oarboxes’ for earlier vessels, but I will utilize the more general term of mounting assembly due to the wide variety of configurations presented in the iconography of the period under study. As with earlier depictions of vessels, there are examples of the ‘wing-like’ planking in this period (see Iconographic Examples 6, 9-11, and 13), although they are not ubiquitous in the examples. The exact configuration and dimension of these timbers are unknown archaeologically, and it is unclear as to how far they extend along each vessel. They often appear to incorporate the wales in their configuration. It is unlikely on a structural basis that the wales continued from the stem to the stern quarter where they flare out away from the primary hull planking. This would render such a timber virtually ineffectual for longitudinal stiffening and no longer functioning as a wale. A more likely scenario would have a series of timbers covering an oar box, or similar rudder attachment, that were tied into the hull at the most sturdy attachment point, that being the wales (this is clear in Iconographic Examples 9 and 16). From the typical side perspective of the artistic representation, it would be difficult to represent where the timbers were attached to the hull. In some instances, it certainly appears that these coverings did extend along the majority of the hull’s length. However, these appear to be a series of planking timbers that not only cover the rudder attachment, but serve as a splashguard along the sides of the vessel (see Iconographic Example 13). There was undoubtedly typical planking and wale timbers

as a potential maximum cargo capacity.

172 Rounded hulls typically have a deeper draft than boxy hulls of similar cargo capacity, which provides greater lateral resistance based on amount of hull beneath the waterline. However, the flatter sides of a boxy hull are closer to perpendicular to the direction of motion than the angled sides of rounded hulls.

174 Casson, Ships and Seamanship, p. 226.
lying behind these ‘wing-like’ projections. In depictions where there are no timbers covering them, mounting assemblies appeared as either small box-like structures (see Iconographic Examples 3, 4, and 15), “L”-shaped timber configurations (see Iconographic Examples 5, 7, 12, and 18), or were in one odd instance were running under the wales (see Iconographic Example 8).

**North Sea merchantmen**

Both archaeological examples of indigenous North Sea merchantmen that we have are dated to the earliest part of the period under study. Although these merchantmen had a similar length-to-beam coefficient to Mediterranean merchantmen, they had different hull shapes. These North Sea merchantmen possessed flatter bottoms, little, if any, deadrise, and sharper bilge turns than their Mediterranean counterparts. Such designs were made possible due to the use of thinner planking and the method of nailing planks to frames, as opposed to the utilization of mortise-and-tenon joints within thicker strakes as in contemporary Mediterranean merchantmen. These ships used single plank strakes of oak, a naturally strong wood, but because of their thinness, a great deal of strength was not derived from the outer hull. However, these thinner planks were more easily bent into the place and allowed the formation of more box-shaped hull cross-sections characteristic of these vessels.

With little strength derived from the hull planking, internal timbers were more heavily relied upon in the North Sea merchantmen, especially through the attachment of robust oak frames to thick keel planks. Although the shape of the keel planks with their very low aspect coefficients did not offer the same resistance to vertical flexing as did keels with pronounced molded dimensions found in the Mediterranean, these thick oak timbers provided sufficient strength when attached to every frame. An advantage provided by keel planks was that the vessels were less stiff, an important consideration in the rough North Sea waters where some flexing helped to absorb the strong forces acting on the hull. As opposed to using internal planking joints, such as mortise-and-tenons or dowels, shipwrights in this region nailed the relatively thin planking directly to the frames and post timbers. These nails typically passed through pre-driven treenails, and were clenched to better resist shearing forces. In the Blackfriars ship, for example, treenails passed through frames but not the planks, indicating a greater concern for frame than for planking integrity, as the former provided the primary source of strength in the hull.

From the limited propulsion and steering evidence available, it seems that rigging and steering gear for North Sea merchantmen were similar to that used in the Mediterranean. Square sails, presumably with brails, have both archaeological and iconographic foundation, and there is no evidence for exclusively rowed merchantmen from the North Sea. Similarly, the available evidence substantiates the probable utilization of quarter rudders.

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175 Artists producing three-dimensional ship representations cannot be expected to have represented all elements that would have not been visible to the viewer, such as the timber behind these ‘wing-like’ projections. Hence, the possibility for misinterpretation of the few examples by investigators.

It appears that Briton and Germanic indigenous ship construction of the first to third century was somewhat less labor intensive than was Mediterranean ship construction during the same period. The labor savings were primarily due to not having mortises to cut, tenons to carve, or joints to align in addition to driving nails or trenails through the planks and frames. Thus having only to drive iron nails through trenails to secure the strakes in place was a more rapid operation to perform. Furthermore, thinner planking attached to pre-erected frames made possible more box-like cross-sectional hull shapes that provided more hold space. These were benefits that could not have eluded the attention of Roman shipwrights and ship operators during centuries of interaction. Hence, many of the basic construction characteristics of these indigenous-built North Sea craft from the second and third centuries represent similar trends in the Mediterranean that arose during Late Antiquity.

Utility vessels: riverboats, bay vessels, and fishing boats

Utility vessels from the lower Rhine region had hulls rectangular in section with flat bottoms without keels and flat ends that were, in fact, ‘floating boxes’. This was an extremely efficient design for maximizing hold space. Their design also facilitated stable maneuvering, beaching, loading, and unloading in relatively calm and shallow fluvial environments. The strength of these vessels was primarily derived from the thickness of their oak planks, although they employed heavy chine timbers and, at times, small proto-keelson type timbers for additional stiffening. Without heavy wave action, there were not the extreme hogging and sagging forces acting on their hulls associated with seagoing vessels. Hence, these river vessels could be designed with high length-to-beam ratios without the imperative to employ large longitudinal timbers, such as a large proto-keelson and stringers, to provide strength.

Beaching of these utility vessels was facilitated by their flat bottoms and flat, angled ends. If such a vessel had had posts, offloading when beached would have had to take place over the fore or stern quarters, and the narrowing ends would have provided less operating room. Because the ends were nearly as wide as amidships, the flat bow and stern increased the offloading area. The heavy bottom planks also provided crucial support during landing, as a beached craft rested partly out of the water. Thus, the landed portion underwent far greater stress on its bottom planks than when in the water. A boat with a keel and posts would also have had the stress of the vessel’s weight concentrated on a small portion central timbers that was in contact with the ground, nor would it have sat evenly or remained stable on a bank. Flat-bottomed river craft spread the stress over the entire bottom resting on the bank and provided more stability when beached.

An interesting characteristic of some lower-Rhine vessels was the use of paired frames at a frame station. Upon first examination, it may appear that shipwrights were attempting to bolster hull strength by pairing the frames. However, the paired-frame stations often had greater center-to-center spacing between them than those with a single frame at a station. This arrangement counteracted the advantage of having a higher number of frames by creating greater spans of hull bottom without frame support. In essence, the
paired frames acted as single large frames spaced widely apart. The pairing of frames also made little
difference in the support given to the hull sides compared to what would have been the case had there been
a closer spacing of single frames. Each frame in the paired arrangement had an attached futtock to support
the side of the hull, each pair of frames having one futtock on either side of the hull. On the
Zwammerdam 2 boat, for example, the arms were carved from branches attached to and extending from
the framing timber. 177 This arrangement was due to lack of naturally curved branches of suitable shape.

Vessels that operated along the inland and sheltered waterways of Britain had somewhat different
characteristics than those that traveled the lower Rhine. The hulls of the former were not as box-like in
section and did not have the very high length-to-beam coefficients that the northern continental river craft
did. Construction features such as central keel plank(s), or possibly a keel and posts, more closely
resembled contemporaneous seagoing craft in the region. For example the New Guy's House Boat had a
substantial post, trapezoidal in cross-section, and a more rounded bottom than did the northern continental
river vessels, although it had harder bilge turns than contemporaneous Mediterranean vessels. It is likely
that boats on rivers, such as the Thames, also operated in the connecting estuarine environments, which
required hull shapes with superior sailing capabilities than those operating on inland continental rivers.
Considering the long history of wharf facilities at London, larger river craft along the Thames were likely
offloaded by a jetty or dock, making the flat bottoms and ends associated with beaching unnecessary.

River craft operating on the Tiber and the protected waters at its mouth were more similar to
riverboats from Britain and Mediterranean seagoing ships than to northern continental craft. These vessels
possessed keels and posts, although the keels did not have as high an aspect coefficient as contemporary
Mediterranean seagoing ships. Likewise, the central longitudinal timbers of river craft from the
Mediterranean region were not as large in cross-section as those of similar-sized seagoing vessels. These
river craft were undoubtedly subject to less intense forces than were those at sea, and thus did not
experience as great a degree of hogging and sagging. However, the increasing percentage of frames
attached to the keel on these river craft follows the same trend apparent in Mediterranean ships as a whole.

Planks on boats operating in the Tiber River were primarily joined with mortise-and-tenon joints. It is interesting that these smaller Mediterranean river craft possess some of the earliest evidence for the
eschewing of mortise-and-tenon joints in planking. The Fiumicino 1 vessel, for example, had repairs
made to the hull planking where only nails were used to attach the planking and frames, and some mortise-
and-tenon joints in this vessel were unpiggled. 178 The planking thickness for these boats in proportion to
overall vessel length was slightly thinner than that of contemporary seagoing vessels.

For utility craft as a whole, there was no typical mode of propulsion. Rather, local conditions

177 de Woerd, “Ships of the Roman period at Zwammerdam/Nigrum Pullum, Germania Inferior,” pp. 16-
17.
178 Parker, Ancient Shipwrecks, pp. 178-179.
determined the assortment of methods employed. Proper wind directions allowed boats to use sails, while insufficient wind was overcome by towing, punting, and/or paddling. Certain river environments, such as the Nile, were ideal for a combination of the methods, where vessels could use the current when rowing/paddling northward, and take advantage of the wind when traveling southwards. Roman roads ran along western bank of Rhine, studded with forts and towns, from Lugdonium Batavorium to Vindonissa. It is possible that many areas along the river were set up with suitable pathways or secondary roads that allowed towing. The high length-to-beam coefficients found on the Rhine river craft allowed improved handling for punting and towing. Likewise, riverboats from the Mediterranean region were slightly more elongated than contemporary Mediterranean seagoing vessels, which facilitated their being towed and rowed.

The modes of steering were also varied on utility craft. The long, narrow barges of the lower Rhine were often controlled with bow and stern oars when not being towed or paddled. When under tow they could use a single stern oar, whereas when drifting or sailing they may have needed the increased control that a combination of bow and stern oars provided. From the limited archaeological and iconographic evidence available, river vessels from both the Thames and Tiber were most likely fitted with two quarter rudders.

A considerable number of details are known about fishing boat construction from both archaeological and iconographic evidence. At least two small fishing vessels were excavated from the lower Rhine, the Zwammerdam 1 and 5 boats, both essentially small, reinforced dugouts. Each boat was under seven meters in length and possessed small decks with rectangular openings that were probably for storing gear, nets, in addition to the day’s catch. Depictions also portray these fishing vessels with an open portion in the decking at amidships. These craft were predominately rowed, an attribute common in every period of history, as it was the most practicable and economic mode of propulsion. It seems logical that the oars were often stowed when the fishing nets and lines were being worked, and may account for an artist’s omission of modes of propulsion in illustrations. There was probably very little difference between the way small Mediterranean fishing vessels of the Late Empire and Late Antiquity were propelled and worked and those operating on the coasts of Mediterranean countries today.

**Seagoing warships**

Without extant remains of warships, there is little that can be asserted with absolute certainty about their construction. However, it may be assumed with some confidence that elements of construction found in merchantmen, such as plank fastenings, internal support, and order of construction, were paralleled in warships. Likewise certain well-documented construction trends in merchantman construction that were economically beneficial from a capital investment standpoint would have also

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benefited the warship construction industry. For example, the decrease in material and labor investment would have allowed warships to be built more cheaply, or more ships to be built with a given amount of financing.

A decrease in the use of mortise-and-tenon joints, generally lighter hulls, and thinner planking for warships would have had other beneficial consequences. Decreasing the weight of the hull would have been most advantageous to warships when rowed. They could be rowed at greater speeds with the same number of oarsmen, or be rowed for longer periods at given speeds. More efficient use of the wind when under sail was also a potential advantage of lighter warships. Thinner hull strakes would have also had repercussions on tactics. Vessels of around the second century had thicker strakes with numerous, large, and closely spaced mortise-and-tenon joints.\textsuperscript{180} A ram striking these earlier hulls would have created damage to a larger area of the hull due to the inherent resistance of thicker strakes and the high degree of strake integration. Later hulls that featured thinner planks, with fewer, smaller, and widely spaced (if any) mortise-and-tenon joints, may have incurred less damage from such blows due to the thinner strakes more easily giving way at the point of impact since they were not integrated to surrounding strakes in the hull.\textsuperscript{181} Less area of hull damage from ram impacts, and possibly less water intake from the compromised areas, would have surely been advantageous in the rare instances when ramming may have occurred. Greater speed and maneuverability of these lighter warships, when under oared propulsion, would have also made both offensive and defensive tactics more effective against heavier, slower vessels. This was undoubtedly the most significant advantage for warships, as it would have greatly benefited tactics utilizing projectile weaponry.

Warships unquestionably utilized both sail and oar propulsion. A square sail with brails set on a single yard was the predominant configuration observed in iconography. The number of warships shown with sails in depictions from circa 50 - 250 and circa 250 - 450 is slightly more than those without a raised sail or mast. Those warships shown without sails may not have necessarily lacked them, for instance, the ships may have been depicted in an attack maneuver where sails and masts were lowered while under oar. Furthermore, although warships were sometimes depicted with a single sail, the vessel was undoubtedly outfitted with two masts. For example, an artemon was shown alone in the period from circa 250 - 450, and must have been part of a two-mast arrangement, since they were shown in conjunction with main masts in all other depictions. It would be prudent and logical for warships to carry sail in order to save the oarsmen's energy for naval engagements, and to provide a greater traveling range for longer periods of time.

Based on the corpus of evidence available, warships from the mid-first to seventh century

\textsuperscript{180} Again, this is assuming that the trends for warships followed those of merchantmen.
\textsuperscript{181} Furthermore, the time and expense of repairs would be drastically reduced; time often being a crucial factor during war.
exclusively had a single bank of oars. The single clear statement about the number of oarsmen on warships was that there were a total of fifty men, a realistic number for a single-bank vessel that resulted in twenty-five oarsmen per side.\textsuperscript{182} In order to provide approximately a meter of space for each oarsman to row, and an adequate length at the bow and stern, the ship would need to have been around 28 to 32 meters in length.\textsuperscript{183} Vessels of such size are common in the archaeological record into the third century, although they were merchantmen, and they testify to the ability of shipwrights to construct vessels of this size. Such large vessels would have likely required two masts when under sail, which is, in fact, observed in depictions of warship. A later shift to a single mast in depictions (a decrease in depictions of \textit{artemens}), in circa 250-450, may well indicate a decrease in the average size of warships. This is similar to the contemporary trend that took place in merchantmen based on archaeological evidence. A decrease in the number of wales shown in warship illustrations may also support this suggested trend of warships becoming smaller from circa 250 - 450 (Chart 53).

Iconographic evidence also allows some insight in the types steering structures on warships. As with Mediterranean merchantmen, warships appear to also use a system of two quarter rudders for steering. However, one obvious difference is the lack of mounting assemblies in warship illustrations. Since warships were undoubtedly as large as many merchantmen, they must have required similarly large quarter rudders. It is unclear, therefore, why these mounting assemblies were absent in warship depictions. It is possible that they utilized a different method of securing quarter rudders in place, perhaps a beam at deck level that would not prove conspicuous in minimalist depictions. Stern structures were also evident on warships. However, it is unlikely that these structures represented the upper portions of galleys as with merchantmen. Their particular configuration suggests that they were for the protection of individuals from the elements and missile fire, while they maintained an eye on the operations of the ship. A further discussion of their significance follows below.

A characteristic component of warships that is virtually taken for granted by scholars is the presence of a ram at the lower portion of the stem. While it is likely that some of the projections in depictions indeed represent rams, there is evidence that suggests not all of these projections can be equated with rams. For example, there are vessels shown with concave bows and ram-like projections, which clearly depict merchantmen, although such configurations were quite rare in merchantman.\textsuperscript{184} As these sailed merchantmen would not have been fitted with rams, the only logical interpretation for the projection is that they represent a cutwater. A concave bow with a cutwater would provide a fine entry for a

\textsuperscript{182} Aelian, \textit{Historical Miscellany}, 8.17. This is presuming that there was a single man per oar.

\textsuperscript{183} For example, although of a different tradition, the Nydam ship had 15 oarsmen per side and was 21 meters in length; a man per oarsmen, results in six meters to accommodate both ends of the vessel.

\textsuperscript{184} There is the example of the Madrague de Giens vessel that was equipped with a cutwater. P. Pomey, "Le navire romaine de la Madrague de Giens," \textit{Comptes Rendus de L'académie des Inscriptions}, pp. 136-152.
merchantman and allow for minimal increased speed under sail, although it would have restricted hold space in the forward half of the ship. Although, it is possible that a cutwater assembly could be added to a typically full convex bow without sacrificing hull space. Hence, when interpreting stem projections depicted on warships, and having no archaeological evidence to the contrary, one must also consider the possibility that they are cutwaters.

There were various implications if projections on warships were cutwaters and not rams. Oared vessels with a cutwater would have had finer entries and possibly attained higher speeds or longer rowing durations. They would also have had a speed advantage under sail, and not burdened with the need for maximizing hold space that governed merchantman design. Although these advantages would be served by cutwaters or rams alike, cutwaters would not have permitted ramming tactics. Furthermore, there would have been decreased labor and material expenses associated with building warships fitted with cutwaters compared to those with rams. The question then arises as to the type of offensive tactics employed if these were not rams. In Chapters VI (The Role of Military Vessels in their Socio-Political Contexts) and 7 (Conclusions) the hypothesis that there was a continued movement toward the use of projectile warfare associated with naval vessels in lieu of ramming tactics will be more fully explored. It will suffice to note here that the frequency of screen on warships increased in depictions from circa 50 - 250 compared to those in circa 250 - 450. This may represent efforts to protect the ships from missile weaponry.

River warships and military transports

Due to their distinct function, river warships had different overall shape and design characteristics than utility vessels operating on rivers. Military vessels were constructed for speed and maneuverability under oar, without considerations for maximizing cargo capacity. Hence, they had fine entries and exits, with softer bilge chines, than did utility vessels used on the river systems of Europe. One common feature was their higher length-to-beam coefficients than contemporaneous Mediterranean river vessels. The shapes of river warships followed many of the trends of Mediterranean seagoing vessels, changing from rounded cross-sectional shapes in the first/second century to flatter bottoms and sharper bilges by the fourth century. However, this change preceded that of Mediterranean merchantmen by at least two centuries.

Further trends in military river craft that paralleling those in Mediterranean merchantmen included the lack of mortise-and-tenon joints, thinning of hull planking, and possibly some frames preceding strakes in the construction sequence. The fourth-century Mainz vessels had the box-like hull sections and thinner hull planking similar to those of the indigenous-built seagoing vessels found in Britannia. For example, all the Mainz Type-A craft had length-to-planking thickness coefficient values of over 10.0, which is higher than that of contemporary Mediterranean craft. Moreover, there was an explicit
lack of mortise-and-tenon joints in the construction of all the Mainz vessels. Longitudinal and transverse support timbers diverged from the trends found in Roman merchantmen and followed those of indigenous North Sea vessels and river craft, such as the New Guy’s House Boat. By the fourth century, military river craft were using central timbers more analogous to a thick keel-plank than to a true keel, while frames were becoming larger and spaced farther apart. Frames and futtocks were sometimes scarfed to one another, such as in those seen on the Mainz B-3 vessel. These were construction features that would be seen, to some degree, later in Mediterranean merchantmen of the seventh century.

Roman military craft operating on rivers required two types of propulsion in order to respond swiftly to a need to travel upstream or downstream on short notice. Both the Oberstimm and Mainz vessels were outfitted for oars and sail, and their high length-to-beam coefficients made possible a greater speed under either mode. Their shallow drafts allowed these vessels to penetrate the shallow waters of tributaries. Type-A Mainz and the Oberstimm craft lacked the flat planking runs characteristic of oared vessels, but their high length-to-beam coefficients compensated for this by providing a long and slight curvature along the plan view. This curvature of the hull in plan view also provided increased beam at midships for greater stability under sail. All evidence indicates these warships used a pair of quarter rudders attached to a single transverse timber, without resorting to the use of elaborate mounting assemblies.

Certain aspects of propulsion in river warships during the Late Empire are an enigma. For example, the few warships portrayed on Trajan’s column had two banks of oars, while the archaeological examples consistently possessed one bank. Also, depictions of seagoing warships from circa 50 - 250 show only a single bank. Moreover, the biremes on Trajan’s column displayed a staggered placement of oars, indicating that rowers were not seated directly above and below one another. The period and source of these depictions introduce several problems. As nearly all of these are from the same source, it is difficult to filter out the traits of a particular artisan. Additionally, the warship depictions differ from the archaeological examples found even though both sources are nearly contemporary.

There are several possible solutions to these problems. One is that biremes were never present on the Danube, and the relief merely serves to communicate the greatness of Trajan’s achievement to the people of Rome, a panegyric with inevitable exaggeration. These reliefs would have recalled the imagery of an earlier, ‘golden era’, which suggested the glory of the Emperor’s deeds by association with certain imagery. However, other military elements illustrated in the column are not notably exaggerated, and it would seem unlikely that only the ships were embellished for propaganda reasons, while the other elements, such as wagons, ballistae, cavalry, and hand weaponry, were not.

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185 Höckman, “Late Roman River Craft from Mainz, Germany,” pp. 23-32.
186 Ibid., p. 31.
The theme of Trajan’s column represents a large campaign, and it is conceivable, therefore, that some larger vessels were brought from the Black Sea to the mouth of the Danube for this campaign, but did not normally operate in this environment. Both of Trajan’s campaigns in Dacia in 101 - 102 and 105 - 106 were included on the column. The second Dacian campaign was one of the largest military operations undertaken by the Empire, and included some twelve or more legions. These unusual circumstances may account for the incongruous depictions of biremes in a river environment. Structures shown on these warships, such as rams, suggest that these vessels should more likely be identified as seagoing warships. There was clearly no need for a ram on river vessels, since there were no enemy fleets with which to engage using ramming tactics. It is also unlikely that river warships were utilized to ram river barges, or small dugouts, as the opportunity to do so would have been extremely rare. Due to the convex bow configurations in archaeological examples of river warships, the concave bows depicted on Trajan’s column also most likely indicate seagoing warships fitted with rams or cutwaters. Additionally, these ships are consistently shown with stern structures similar to those found in seagoing warships, a nearly non-existent feature in other river warship depictions.\textsuperscript{187}

Furthermore, on the basis of effectiveness, navigational operation and tactical utility, biremes were unsuited for riverine operations. Their great draft and large size rendered them ineffective for tributary travel, or rapid maneuvers. However, they may have been brought up into the deeper river mouths for increased missile support and/or used as ad hoc troop transports. It is more likely that boats akin to the Oberstimm vessels were operating on the Danube in the first and second centuries. Thus, the biremes on Trajan’s column were probably seagoing warships that had been brought in for increased missile support and troop transportation; but they remain inconsistent with all other contemporaneous representations of seagoing warships. Assuming that these ships were part of a seagoing fleet, they were most likely part of the classis Moesica, although for these large campaigns, fleets certainly could have included ships from other fleets or vessels pressed into service.

Assuming that these biremes were seagoing warships, they were the only such vessels shown with more than a single bank of oars in the period of study.\textsuperscript{188} Thus these anomalous warships were either the only chance representations of biremes surviving in the archaeological record, very rare ships that did not survive in use after the early second century, or were inventions of the artist. That these illustrations represent the chance rare depictions of what were actually common vessels is very unlikely considering the sample of illustrations available. With twelve legions involved in the operation, there must have been numerous high-ranking military officials traveling to the scene in addition to the Emperor himself. Thus it is possible that the relief on the column depicted a few anachronistic biremes, similar to the imperial

\textsuperscript{187} As quarter rudders were common to all ships, they cannot be utilized to differentiate ship types.\textsuperscript{188} These vessels were not categorized in the tally of vessels represented in a sea setting because they were technically shown in a river environment.
flagships that operated out of Misenum and Revenna, used to convey high-ranking officials. Such biremes would not have been the typical ship of the line for the fleet, but holdover ceremonial vessels from an earlier period that were traditionally used for transporting the highest ranking officials and conveyed the message of superior power to enemy forces. It is also possible that the artist drew on earlier motifs of biremes to signify the arrival of the Emperor and other high ranking officials.

Whether the warship depictions on Trajan’s column were actual or fictitious anachronistic craft, or ceremonial sea-going warships operating upstream, taken as a whole they portrayed significantly fewer screens than did river warship depictions from circa 250 – 450. This increase in the depictions of screens is analogous to a similar increase found on seagoing warship depictions from the same period and supports the continued movement towards increased projectile warfare utilized by warships. It is noteworthy that depictions of transport vessels from the sixth century appear to have screens made of shields (although the identification is tentative). This would be consistent with the necessity for screen protection on both sea and river warship depictions in later periods where projectile weaponry was in greater use.

Our information for the use of river transports in a military setting also comes exclusively from Trajan’s column. These craft were depicted in a most cursory manner when compared to other vessels shown on the column, not having deck structures, screens, or bow projections at the waterline. Several oars over the oar strake (or cap rail) and a quarter rudder system were typically represented. Höckman argued that the rather tubby Type-B Mainz boat was a touring vessel for a dignitary.\(^{189}\) While this is certainly a possibility, a simple and more plausible explanation is that this was a transport vessel for moving equipment, troops, and possibly horses.\(^{190}\)

**Ship decoration**

As with all types of decorations, those found in ship iconography served as both symbols and signs. As symbols, decorations included totems of deities (a tutela), cultural and/or state affiliations of the owners/operators, and possibly associations with ancient maritime folklore. Decorations serving as signs could indicate the affiliation with trade guilds (collegia), designate the unit or rank of officer on board, or communicate other information to other vessels.

There were several common decorations on seagoing and riverine vessels that could have been produced by simply carving the ship’s existing timbers, or by attaching decoratively shaped independent timbers. For example, the flat terminus found on stems and sternposts could have been formed by carving

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\(^{189}\) Höckman, “Late Roman River Craft from Mainz, Germany,” p. 31.

\(^{190}\) Designating this vessel as a transport calls into question its reconstruction with extensive decking and a structure amidships; as a transport vessel would likely have had only a small deck leaving a large open area for carrying cargo. Moreover, there is no compelling archaeological evidence for this vessel being decked.
the ends of the post timbers. As the posts were cut from larger timbers and later fared down to the proper
shapes and dimensions needed for the hull, it would be a simple and time saving endeavor to leave their
free ends wider for decorative purposes. A more elaborate decoration (but not exceedingly difficult to
accomplish) would involve the carving of a volute from this upper, free end.

Forward or inboard projections were likely formed by attaching a timber to the upper portion of
either the stem or stermposts respectively. By scarfing or simply nailing a timber to the end of a post, its
apparent curvature could be continued and altered to create a more pronounced projecting profile. Many
of these projections also ended flat, thereby maintaining the appearance of a single continuous post timber.
There was a greater occurrence of forward projections on the bows of ships from circa 450 - 650 (Chart
51). This transformation may possibly be a result of the changing cultural constituency of the various
political entities engaged in shipbuilding and trade during the fifth through seventh centuries. Another
change in decorative motifs was the appearance of animal and bird heads on post ends of after circa 250.
This was arguably a result of interaction with the Germanic and Scythian cultures along the river systems
of Europe and the Black Sea, and their integration into the military.

There is a suite of iconographic elements that may have together designated larger warships. Of
the seven depictions from circa 50 - 250 with standards shown in the stern, six also had stern structures
and *artemos*, and five had deck projections (Chart 54).\(^{191}\) Standards were typically carried to designate
the ships of high military officials, who were likely seated in these stern structures. Standards, *artemos*,
stem structures, and the goose motif near the top of the sternpost commonly found together in illustrations
from circa 50 - 250, decreased, or disappeared, in depictions from circa 250 - 450. As *artemos* were
likely suggestive of larger vessels, this entire suite of elements may also correlate with larger
merchantmen and warships. The goose motif on Roman merchantmen may have designated official state
sponsorship on the largest and most prestigious of ships, and thus appeared on the larger warships that
carried officials.

The *aphlaston* in the stern of these warships typically had three projecting arms, and appeared to
have no functional purpose. This decoration has a long history in depictions of Mediterranean warships,
going back to the Archaic period warships of the Greek city-states. Its continued use into the Roman
Empire may have been a result of its association with the stylized tail feathers of a goose. Conversely, it is
certainly possible that this element was only apparent in later iconography as a mechanism to
communicate ancient power, and was not actually a decorative element. Without archaeological evidence,
it is impossible to determine its presence with certainty. Though it continued to adorn Roman Imperial
warships in depictions, it began to disappear after circa 450. Hence, there were possibly no traditional
Roman ships at sea after circa 450, and the Eastern Roman Empire presumably had its own set of symbols
for ship decorations and/or iconographic representation.

\(^{191}\) A single vessel with standards had no other elements shown.
The deck projection, however, most likely had a functional rather than a decorative role. Some reconstructions of merchant vessels and warships present it as a platform shown in profile with railing or a screen. Casson alludes to this configuration as a possible 'poop deck'. As this structure is often depicted as beginning forward of stern structures and continuing behind them, it is probably two gangways that run aftward along each side of the extreme stern, joining at a small, stern platform. Such a gangway and platform essentially extended the vessel's deck, and may have been utilized as a signaling or work platform. However, the consistent angle at which the projection was depicted renders it dubious as being an effective platform for other than for quick access or temporary soldier positioning. It may have represented a narrow gangway that allowed sailors access to the extreme stern areas where backstays, mooring lines, and signaling paraphernalia were located. Such a deck projection may have been useful on larger vessels, such as those carrying high-ranking military officials that had to give signals to the fleet, but not necessarily on smaller ones. One frequently cited possibility for the deck was that it functioned as an officers' head.\(^{192}\) That this structure had only a single purpose, or usefulness, is unlikely and after it was developed to solve a particular problem, it was utilized for a variety of conveniences. The rendering of the deck projection follows the same pattern in both merchantmen and warship depictions: it is prominent in illustrations from circa 50 - 250, but scarce in the subsequent periods. In depictions of merchantmen, it is only found associated with the goose decoration. Thus, deck projections may have also been associated with larger vessels with there being a decrease in both large merchantmen and warship sizes after circa 250.

Banners flying atop masts could have indicated private trading collegia, political affiliation, fleet signals on military vessels, or were more practically used as indicators of wind direction and speed. Although seen in a number of depictions from circa 50 - 250 and from circa 250 - 450, there was a significant decrease in the number of banners in depictions after circa 450. This decrease may be a result of a shift towards the less-realistic style that characterizes the period's artistic conventions, or it is possible that these banners did have some sort of signaling value, such as for collegia, and were no longer used when these affiliations disintegrated in the fifth century.

There was a conspicuous lack of oculi on merchantmen, warships, and utility vessels in depictions from all periods. This symbol has been traditionally associated with Greek cultural influences on ship construction and operation, and was often copied in Roman ship depictions of the early Republican period. With the cities in Achaea and Macedonia having been long since relegated to a minor role in the socio-political world of Late Antiquity, it is not surprising that there are so few depictions of 'Aegean' ships. Although Greek poets and playwrights remained in favor during the Empire, any

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significant technological influences on ship construction from the Greek peninsula had, in my opinion, long since ended.\textsuperscript{193}

Depictions that exhibited little regularity in decoration were those of fishing and pleasure boats. Decorations varied widely among the vessels and often covered more of the hull than shown on other ship types. The various and ornate decorations on these boats seems quite logical, as they were most likely operated by single owners who took more liberties in expressing their individualistic decorative tastes. It may seem incongruous to elaborately decorate such a functional vessel, but in many areas of the Mediterranean today one may view small fishing boats are decorated with a combination of colors, flags, and other paraphernalia.

\textsuperscript{193} This is assuming that they had actually been in the forefront of technological developments in an inventive role and not borrowing from other cultures.
CHAPTER V
THE SOCIO-ECONOMIC RÔLES OF MERCHANT AND UTILITY VESSELS

Introduction

Innovations in ship construction were driven largely by traders' attempts to carry more cargo in ships that required less capital investment of resources. Greater cost effectiveness was accomplished through gradually building lighter, roomier vessels. This required that the ship undergo fundamental changes as a vehicle of conveyance for trade goods. Merchantmen were simply a transportation vehicle for moving cargo from point to point. Thus, their design and construction were overwhelmingly dominated by economic concerns rather than ideology or symbolism. The utilization of less wood in the construction process would have reduced capital investment and potentially made each venture more profitable compared to voyages undertaken by similarly sized vessels built with more materials and labor. Decreased capital investment combined with increased cargo capacity resulted in more profitable trading operations by the end of Late Antiquity than had occurred during the Late Empire. A greater efficiency was also realized in the maintenance costs of such vessels; repairs to hull planking were simpler and less time-consuming in the absence of mortise-and-tenon joints. It is thus crucial to examine the overarching economic events of Late Antiquity and the role of merchantmen in order to understand how these changes in design and construction came about.

The technical trends of transportation technology discussed in the previous chapter emerged from distinct events and economic environments during Late Antiquity. For merchant and utility vessels, the primary developmental mechanisms associated with transportation technology were trade, redistribution, fishing, and ferrying. The second through fourth centuries in the Mediterranean and Europe were dominated by a vast and integrated Roman Empire overseen by a large central bureaucracy whose maintenance required the extensive and systematic transportation of goods. As a result of this efficient centralization, aristocratic elites and merchant cooperatives enjoyed a relatively peaceful environment in which to conduct their trade. Border incursions and subsequent losses to Germanic and Scythian invaders resulted in diminished Imperial territories by the fifth century. New Germanic and Scythian kingdoms quickly integrated themselves into the trade networks of the Mediterranean and Europe and themselves benefited from active sea and river trade.

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1 There were numerous cost factors, such as increased income on trading ventures and greater return on capital investment, involved other than simply attempting to replace mortise-and-tenon joinery with less labor-intensive techniques. These will be discussed throughout the chapter.
Shipping and the Annona

The Empire's *annona* system was one of the primary institutions that placed a significant demand on water transportation. At its most fundamental level, the *annona* consisted of the organized collection, shipment, and dissemination of basic foodstuffs (such as wheat, barley, olive oil, and wine) to citizens in large metropolitan centers. Foremost among these centers were the capital(s), regional centers, and other large population centers. Although primary importance was given to the food supply of the capital and regional administrative centers, the *annona* also had other functions such as to alleviate food shortages in the cities, and in the supply of large numbers of military personnel stationed in areas where local production could not meet their demands. For example, special shipments of grain were required in Britain from the time immediately following the first-century invasion until local production could adjust and regular distribution systems be implemented. Even then, due to inevitably poor growing seasons, the destruction of stores, and taste preferences for various foodstuffs from the homelands of the troops, shipments from the Mediterranean continued to be made to Britain by ocean, sea, and river routes.

The Praefectus Annonae, an office created by Trajan (98-117) that endured until the beginning of the fourth century, headed the *annona*'s bureaucracy in Rome. Emperors requested grain through the Praefectus Annonae, who was responsible for organizing the shipments for the populace. The subordinate offices of Procuratores Annonae dealt with grain merchants, grain measurers, and logistics of some river transportation. Further duties included the paying of navicularii and merchants (negotitiores and mercatores), the purchasing of extra grain for the state, balancing shipments with demand, and maintaining a list of shippers in service of the state. Upon arrival in Ostia, the foodstuffs were transported by the naves codicariae to Rome.

Unlike the situation at major receiving ports, the *annona* does not appear to have been highly organized in the source areas of the grain, with fewer officials and overseeing employed in the provincial areas. However, the conspicuous military presence of the legions often guaranteed that local producers delivered their goods to the *annona* collectors and carriers. There did not appear to have been many efforts to control the supply of foodstuffs by manipulating prices. Although Tiberius placed a ceiling

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2 G. Rickman, “The Grain Trade Under the Empire,” in *The Seaborne Commerce of Ancient Rome: Studies in Archaeology and History*, eds. J. H. D'Arms and E. C. Kopp, pp. 270-271. Houston has argued that in dealing directly with merchants, the *navicularii* also oversaw the unloading, measuring, storage, transport of grain upriver, as well as the construction of granaries and other associated public buildings. Although efforts were made to always meet the populace's needs, not all grain was doled out to the people, as some reserves were held in warehouses and sold to the highest bidder: G. W. Houston, “The Administration of Italian Seaports during the First Three Centuries of the Roman Empire,” in *The Seaborne Commerce of Ancient Rome*, pp. 160-161.
price on grain, he was consequently forced to subsidize the shipping costs. Typically each shortage was viewed as an emergency, the solutions to which were often novel and not repeated. Notwithstanding Imperial involvement in the *annona* system, *collegia* were still somewhat independent of the state as late as the third century.

As the population increased and military obligations expanded, the administration became increasingly reliant on the *annona*, and the associated demand on ships to fulfill these quotas also increased. The uncertainties of relying on private shipping to provide these crucial foodstuffs prompted direct government involvement. In efforts to address these uncertainties, Vespasian (67-79) organized the *classis Augusta Alexandri* to secure the Egyptian food shipments. Later, prompted by the plundering of grain supplies and other shipping problems in 190, Commodus organized the *classis Africana* that was to be in reserve if the Alexandrian grain supply failed. Titled the *Commodiana Herculea*, this fleet eventually supplanted the majority of the shipping burden from North Africa by the fourth century. Prudentius’ remark that grain shipped from Sardinia was handled by a *classis* suggests that fleets were undoubtedly operating other routes as well.

Control over these fleets was crucial and was often utilized as a source of political leverage by officials in the source areas of the foodstuffs. In one such instance during the autumn of 397, Gildo rebelled in Carthage, his first act being to suspend grain fleets destined for Rome and instead sending them to newly allied Constantinople. Honorius (395-423) quickly suppressed the rebellion in 398 in order to reestablish the crucial food supply. Likewise in 413 Heraclian, the *comes Africae*, suspended the grain shipments to Rome while on embassy to Italy, and Boniface (*comes Africae* and later *magister militum*) periodically halted shipments of grain to Rome between 423-29. Understandably, the threat of food shortages and subsequent unrest in the capital cities was a potent political tactic, rendering control of the fleets a powerful asset.

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3 Tacitus, *Annals*, 2.87.
5 *Collegia* were private organizations of individuals, analogous to guilds, who conducted the financing, shipping, and distribution of various commodities such as salt, timber, and foodstuffs.
7 Feeding the populace in any city of this period, including Rome, prevented rebellion against the head office.
10 Clover, *The Late Roman West and the Vandals*, pp. 8-9.
A fundamental shift in the pattern of annona shipments occurred in the fourth century. The founding of Constantinople in 330 as the administrative capital of the Empire by Constantine (307-337) effectively split the annona supply along a central Mediterranean axis. Egypt now supplied Constantinople while Rome relied on North African resources. Amphora evidence also suggests that the eastern Mediterranean supplies of wine for Rome, northeast Spain, southern Gaul, and the Western army dropped after the foundation of Constantinople, with an associated dramatic increase in Eastern fourth-century wine amphoras found at Constantinople. Sicilian and Calabrian wines filled some of the void left by the decrease in Eastern imports. Rome’s increased dependence on North African grain is evidenced in the archaeological record. Late-fourth/fifth-century assemblages from Ostia have a higher presence of North African pottery than in earlier periods. Forty-five percent of the mid-second century amphoras were from North Africa, but by the fourth century the region’s representation had risen to sixty percent. During the same time period, fish sauce and olive oil imports shifted from sources in Spain to those in North Africa, and North African crude wares were increasingly imported throughout Italy until the fifth century. North Africa enjoyed an economic boom as long-distance trade increased, as evidenced by the increase of Tunisian wine and fish-sauce amphoras in western ports.\textsuperscript{11}

Private operators found a source of income not only from the Imperial annona contracts, but also from personal secondary cargos. This practice was further encouraged in the late fourth century by the Theodosian Code which made goods shipped with fiscal cargos tax exempt.\textsuperscript{12} The presence of mixed cargos from varied sources aboard ships suggests they were stopping in multiple ports and thus were afforded ample opportunity for acquisition of secondary cargoes.

The significant quantities of foodstuffs involved in the annona system were transported over both seas and rivers, necessitating a variety of transportation craft. Rickman estimates that during the first century approximately forty million modii of grain per year was shipped to Rome.\textsuperscript{13} Assuming this quantity

\textsuperscript{11} Consequently, the increased demand for these foodstuffs resulted in an associated rise in the number of oil farms, press sites, and kiln sites in central Tunisia and other areas: P. Reynolds, Trade in the Western Mediterranean: AD 400-700, pp. 23-78.

\textsuperscript{12} This provided an incentive for trading at numerous ports in order for the ship operators to take advantage of the tax-exempt status of their personal trade goods. By 409, however, it became necessary to issue an imperial law forbidding fiscal ships from stopping at extra ports to trade in order to keep the annona shipments on schedule. It can be inferred from such a statute that these extra profits were not uncommon and assuredly continued.

\textsuperscript{13} His estimate was based on a population of 750,000 to 1,000,000 for Rome and on Josephus’ statement that Egypt and Africa were sending 13,000,000 and 27,000,000 modii per year respectively. (Josephus, The Jewish War, 2. 383-6). The harvest time of grain was between May and June, which meant that
of grain to be a good estimate, and taking into account the ship capacities mentioned by Scaevola (fifty-thousand modii ships being the larger class and ten-thousand modii ships the smaller), we may conclude that at least eight hundred larger or four thousand smaller shiploads were necessary to supply Rome alone. These shipload numbers refer only to grain shipments alone and do not include other foodstuffs such as olive oil and fish sauces that were shipped as part of the annona.15

A brief examination of a few shipping routes can provide one with an estimation of the great number of merchantmen associated with the annona system in the Mediterranean. As discussed in the conclusion of the last chapter, the merchantmen required to carry the legal minimum amounts as reported by Scaevola would have been approximately 23 and 33 meters in length respectively. If half the ships were of each size category, 400 trips by larger ships and 2,000 by smaller ones would have been required per year, or around 34 round trips by the larger ship class and 167 by the smaller class ships each month. If a third of these trips had been destined for Egypt and two thirds for Africa, a total of 11 larger-craft and 56 smaller-craft round trips would have been required for the Egyptian route, and a total of 24 larger and 111 smaller craft round trips were needed on the African route per month. On the basis of a conservative estimate of 10 days to make the round trip journey from Ostia to North Africa,16 a minimum of 8 larger and 37 smaller merchantmen would have been necessary to make the minimum number of round trips. Given an estimated average round trip time of 8 weeks for the Ostia-Alexandria circuit,17 at least 22 larger and 112 smaller class merchantmen were needed to make the necessary number of round trips. These estimates reflect ideal shipping amounts, optimum weather conditions, year-round sailing seasons, best sailing times, and trouble-free voyages. As none of these conditions would have existed, there would likely have been many more vessels needed to complete the required number of journeys. For example, the winter months of each year saw a reduced amount of shipping due to poor weather compared to the rest of the year. These ship numbers for either route are only estimates for providing Rome's wheat requirements and could easily be quadrupled to accommodate other food items such as olive oil, wine, and fish sauces that were also being shipped. Shipments would have also accommodated items such as stone, cloth, fruits, finewares, etc. that were not accounted for in this

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14 Rickman, "The Grain Trade Under the Empire," p. 263; for mention of ships carrying wheat from Alexandria to Rome, see also Acts, 27.38.

15 One example was the generous donation under Septimius Severus (193-211) of a perpetual supply of olive oil in gratis to the people in Rome: Aelius Spartanus, Severus, 18.1-5.

16 Pliny, Natural History, 19.3-4; 15.75; Plutarch, Marius, 8.5. The trip is estimated at three and one half to four days journey each way and two days of loading and organizing.

17 L. Casson, Ships and Seamanship in the Ancient World, pp. 297-299.
estimate. Therefore, considering the number of large and small cities in the Mediterranean and Europe tied into the _annona_ shipping network, as well as the addition of shipments for military provisioning, and the number of ships engaged in the private merchant trade/shipping industry, the number of merchantmen operating was undoubtedly quite high during the late Empire. The fleets operating out of Alexandria and Carthage alone must have consisted of several hundreds of ships just to fulfill their _annona_ duties.

Determining the origin and route of ships, despite the presence of specific cargoes, has always been a difficult task for archaeologists. The financier of a particular cargo, whether it was a part of government or private enterprise, is even more challenging to determine. Of the wrecked merchantmen that have been excavated, some could certainly have served in the _annona_ system or resembled the type of ships that did. As discussed in the previous chapter, the estimated lengths of ships in the second to fifth centuries based on archaeological evidence clustered around 22 and 30 meters, coinciding with the large and small ships noted to have been associated with the _annona_ system. The Torre Sgarrata, Punta Scifo, Giglio Porto, and Punta Ala ships are examples of those falling into the large-sized category, while the Bourse de Marseilles, Point de la Luque B, Port-Vendres, and fourth-century Yassia ships were representative of the smaller size.\(^{18}\)

**Cargoes and Ship Construction**

There were several basic construction requirements for ships involved in the maritime transportation of grain. Grain must be kept cool and dry while in storage and during shipment as it has a propensity for moisture absorption; wet grains can swell to twice their size causing hulls that carried them to split. Problematically, grain also continues to absorb oxygen after harvesting, emitting heat, carbon dioxide, and water. If the temperature of the grain rises to over sixteen degrees Celsius and becomes saturated at greater than fifteen percent moisture content, various forms of contamination, such as fungal growth and the spawning of grain weevils (_Sitophilus granarius_) and of grain beetles (_Oryzaephilus surinamensis_), can result.\(^{19}\) As grains were traditionally carried loose or in sacks, decked vessels were paramount for protecting grain from rain, ocean spray, and condensation at night. Adequately sized hatches in these decks were not only mandatory for loading and unloading, but necessary to allow proper ventilation and temperature control. Law codes from the sixth century stipulate

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appropriate partitioning in a ship’s hold where grain was carried loose, ensuring that spoilage would be kept to a minimum if water entered the hold. Where hulls have been preserved to a sufficient degree, they typically have evidence of some decking. Ceiling planks covering the tops of the frames further protected cargos from bilge water, and of most merchantmen wrecks have provided evidence of ceiling planking.

Wine, olive oil, and fish sauces such as garum were all shipped in amphoras, their remains indicating that great quantities of these cargos were shipped throughout the Mediterranean and North Sea. Amphora types and frequencies indicate that Mediterranean wine was one of the most commonly shipped products to Britain, while the shipment of olive oil and fish sauces to the British garrisons were from sources as distant as the eastern Mediterranean. Baetican olive oil was also sent to the German frontiers in the fourth century after Hispaniae came under the control of the Praetorian Praefect of the Gauls in the Diocletian reforms.

Amphoras are hard objects and with the added mass of their contents they could damage the interior of the hull due to point loads they placed on timbers. Traditionally, dunnage was utilized to

20 Justinian, *Digest of Roman Law*, 19.2.31. The safety of cargoes was particularly a crucial concern for the government’s annona contracts.
22 Since sacks or loose grain spread out on the top of the ceiling, there were not typically point loads on timbers with this type of cargo.
23 In the sixth century Mediterranean merchantmen were described as “brimming with wine”: Justinian, *Digest*, 47.2.21.
24 This is not surprising considering the lack of a native wine industry.
25 Chart 69 outlines a sample of the amphora types located at four fort sites from the northern, central, and southern parts of the province that carried Mediterranean foodstuffs. Amphoras that carried cargo from the Mediterranean are also found on shipwrecks around Britain. The Little Russel A vessel, found near the Channel Islands and dated to the late first to early second century, carried a cargo of fish products in Beltran 2B amphoras from southern Hispaniae: Parker, *Ancient Shipwrecks*, p. 244. Neither the protein nor fat calories from these food items were necessary, thus leading one to believe that the demand for them was culturally based. The majority of troops in Britain originated from areas near the Mediterranean or from places which had been in contact with the Mediterranean culture for many years. Hence, some specific Mediterranean food items followed the troops to Britain.
26 S. J. Keay, J. Carrete/Nadal, H. CarreteM, and M. Millett, *Roman Provincial Capital and its Hinterland: The Survey of the Territory of Tarraconensis, Spain*, 1985-1990, p. 190. Olive oil was typically transported in Dressel 23 amphoras. However, pottery assemblages indicate some decrease in imports of wine and oil along the Rhine after the mid-fourth century from North Africa and the Eastern Mediterranean. Danubian imports were also limited to grain; no oil, wine, or secondary commodities are
protect the ship and containers from one another, forming a padding atop the lining of ceiling planks. The lining of ceiling and stringers not only provided protection, but also formed a platform that allowed easier stacking of the amphoras and removed cargo obstruction in order for bilge-water flow. Without ceiling planks in a ship’s hold, an irregular foundation of frames would make the stacking uneven and less effective. Spillage, broken amphoras, and other refuse could also be more easily cleaned from the surface of contiguous ceiling planks than from the spaces between frames. To keep amphoras from shifting, they were typically stacked in patterns of offsetting layers whereby jars in the upper layer nestled into the spaces between jars in the underlying layer. Further dunnage could be used to fill in the open spaces between amphoras and cushion their contacts when jostled.

Shipping of Foodstuffs in the Germanic and Scythian Kingdoms

For centuries Rome utilized lands in North Africa and Sicily as a source of foodstuffs and moved them through the amnona system. After the conquest of these areas by the Germanic and Scythian populations from the East, the Empire no longer had access to much of these crucial food production territories. The Vandal government situated in North Africa was able to sell the produce of the lands within their state, as opposed to sending it to Rome in the form of an amnona tax as had been done before their arrival. Thus these rich agricultural lands were an important source of trade revenues for Vandal North Africa and their shipping infrastructure the most crucial component in effecting Vandal trade. As a result of Vandal takeover, the targeted areas for export of North African produce shifted from an emphasis on Italy to Spain and other western Mediterranean ports in search of profit rather than a fulfillment of tax levies. Procopius reported that merchant ships were commonly traveling to and from the ports at Carthage to those in southern Spain. Excavated sites along the southern Spanish coast contain increased quantities of North African amphoras, African Red Slip ware (ARS), and North Africa coarseware in their ceramic assemblages. Consequently, the percentage of Tunisian amphoras in assemblages from Rome, Naples, and Capua decreases after the mid fifth century, and continued decreasing throughout the sixth century. However, the importation of food from North Africa to Italy

found in significant amounts. These changes are a result of the regionalization of the military economy as these areas became more self-sufficient.

27 Prudentius, writing at the end of the fourth century, states that African wheat was still crucial to the food supply of Rome, and was shipped to the mouth of the Tiber (Portus): Contra Orationem Symmachii, 2, 937-943.

28 Procopius, History of the Wars, 3.24.11.

29 Reynolds, Trade in the Western Mediterranean, pp. 114-116. Late fourth/fifth century kilns for production of garum amphoras were excavated at Carthago Nova: Keyt, et al., Roman Provincial Capital, p. 190.
was not terminated, as indicated by a representation of Tunisian amphoras in Italian ports at fifty percent or more during the fifth century. Ports now ignored by the Vandals in the West opened up opportunities for Eastern traders as well as smaller regional operators, and there is an associated increase in the percentage of late fifth/early sixth century Eastern and local amphoras found in Italian port excavations. Procopius also observed that native and Eastern merchants resided in quarters next to the sea at Carthage and north of the harbor district. Archaeological evidence from mid fifth-century shipwrecks near Sicily further substantiates a strong affiliation between Italy and the Eastern producers. Two such examples are the Cefalù wreck that carried a mix of African and Aegean pottery and the Verdicari wreck found with a cargo that included Byzantine pottery. The total quantity of North African ARS trade appears to have been virtually unchanged, although exports were increasingly shifted to the East, particularly to Greece and the Levant. This increase in ARS shipped to the East independent of amphoras, and coupled with an increase in eastern amphoras arriving in Carthage, probably indicates a pattern of Eastern wine and olive oil being exchanged for North African grain.

In the later Vandal period, between 500 and 533, ARS continued to be distributed throughout the eastern Mediterranean. However, most notable was the apparent revitalization of trade to the western Mediterranean. Excavated shipwreck sites from the southern coast of Gaul such as the Mateille

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30 Local producers from Sicily and Calabria filled the void in the wine supply to Italy created by the Vandal control of shipping routes in the Central Mediterranean. Local wine amphoras are found at Rome, Naples, and Capua: Reynolds, *Trade in the Western Mediterranean*, pp. 114-116. North African amphoras were found on the Filituci Porto wreck from Italy, providing evidence that some food continued to be shipped to Italy: L. Bernabo-Brea and M. Cavalier, "Archeologia subacquea nelle Isola Eolie," *Archeologia Subaquea* 2 (1985): 95-97.

31 After 450, Eastern Late Roman C amphoras began to be imported into east-central and southeastern Italy: Reynolds, *Trade in the Western Mediterranean*, p. 113.

32 Procopius, *History of the Wars*, 1.14.7-17, 1.20.5-8, 3.20.15.


35 Consequently, there is a contemporaneous drop in ARS representation in Italy. During the first half of the fifth century, Eastern imports to Carthage were low. Imports increased steadily after 475. An increase in Eastern imports is concurrent with ARS exports to Eastern Ports. Since ARS is a luxury item and a secondary trade good, its presence in large quantities in Eastern ports without associated amphoras points to a perishable cargo as the primary trade good, grain being the most likely. In large part related to this profitable trade with Constantinople and the East was an increase in ARS workshops in northern Tunisia designated for export production: Reynolds, *Trade in the Western Mediterranean*, pp. 112-117.

36 Large amounts of ARS are found at Marseilles, Belo, Valencia, Sperlonga, Pollentia, S. Giovanni de Riote, while some sites, Cherechel, Porto Torres, Rome, Naples, Luni, Ventinglia, and the Albegna valley, were excluded from ARS trade: Ibid., p. 115.
A	extsuperscript{37}, Port-Miou	extsuperscript{38}, and Dramont E	extsuperscript{39} wrecks, as well as those from Italy, such as the Graham Bank B	extsuperscript{40} and Pian di Spille	extsuperscript{41} wrecks, all contained North African amphoras and pottery. Hence, late Vandal North Africa had vigorous trade networks throughout the Mediterranean, stretching from Spain to the Levant.

A remedy for the loss of North Africa from the Roman annona system was addressed by Justinian (527-565) in his campaigns of territorial reclamation for the Empire. Justinian reestablished the North African annona supply and utilized it for the western army in their campaigns in Italy, Sicily, and Spain. Sicily also represented a vital grain source for Constantinople in the late sixth and seventh centuries. Consequently, the reintroduction of the annona system depressed the North African economy and ended the majority of its trade with private eastern markets by the mid-seventh century. Likewise, importation of Eastern amphora virtually ended in Carthage by around 600, as the private sector of the shipping trade undoubtedly waned. While there is evidence of a slight decline in ARS production and forms before the Roman reconquest, the Byzantine takeover initiated a sharp decline over the next two centuries,	extsuperscript{42} with ARS disappearing in most Western ports and replaced by Eastern goods. The reconquests of western territories did, however, usher in a reintroduction of some Eastern trade goods into the West as well as some regionalization in Mediterranean trade. From the fifth to seventh centuries, there was an increasingly strong regionalization of eastern Mediterranean and Tunisian amphoras, although lower quantities of fine wares continued to be shipped to a few eastern Mediterranean ports.	extsuperscript{43} The majority of ARS finds in the East are found without the amphoras usually associated with them. This probably indicates that North Africa, in addition to Sicily, were once again shipping grain to the East as part of the annona, but not wine, olive oil, or fish sauce in amphoras.	extsuperscript{44}

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	extsuperscript{39} Making up the cargo were two types of amphoras from Tunisia, some of which contained olive pits: C. Santamaria, "Le pied de mat de l'épave 'E' du Cap Dramont," Archaeonautica 4 (1984): 107-114.

	extsuperscript{40} Finds included Punic amphoras: S. Chiappisi, "I fondali marini della Sicilia e i giacimenti de anfor esistenti," Due Punti 2 (1968): 11-25.


	extsuperscript{42} Although there was a brief reinvigoration of general trade with East between 550 and 575.

	extsuperscript{43} Reynolds, Trade in the Western Mediterranean, p. 119.

	extsuperscript{44} Coarseware production also decreased in North Africa after Roman reoccupation, while Eastern Mediterranean coarsewares are found in increasing quantities from sites in Cartagena, Carthage, Marseilles, and Naples. Fine wares (a secondary cargo) were usually carried along with foodstuffs (a
Long-distance trade was increasingly controlled by the church, and played an important role in the redistribution system. In the early seventh century the patriarch of the Alexandrian church possessed a large fleet of ships, complete with agents and captains, who handled grain shipments as far as Britain. To a degree the church was fulfilling the role of the *collegia* by financing some of the costs associated with the shipment of goods, and were likely financing overseas trading ventures. Interestingly the captain of the seventh-century Yassada vessel was apparently a priest.45 Also the early-sixth-century Favoritix wreck from Spain was transporting a large quantity of metal among its cargo, probably supplying churches on the Balearic Islands after sailing from Syria or Egypt.46

The need to import consumables drove much of the Ostrogothic overseas trade, and King Theodoric (493-526) was frequently concerned with maintaining the regular shipping of foodstuffs to the capital Ravenna in order to prevent riots.47 Italian trade throughout the Mediterranean was spurred not only by local consumption, but also by the enterprises of the Ostrogothic nobility. Ostrogothic leaders and warrior groups reinforced social ties through lavish gift giving, which often required exotic luxury items imported from distant ports.48 Special cargoes were also shipped from various parts of the Ostrogothic kingdom to Ravenna for use in the royal palace, as when Cassiodorus organized the shipping of Bruttian wine and cheese to Ravenna as an indulgence for King Theodabod (534-536).49

Cabotage was prevalent among the dioceses of the Ostrogothic Empire, much of which was conducted by ships. Located in extreme southwest Italy, Bruttium conducted sea-born trade from both its coasts and subsequently became a very wealthy diocese under the Ostrogoths. Its trade was based on a surplus of agricultural production, including cattle, wine, and olive oil. Much of this production was specifically designated for export and provided a lucrative source of tax revenues for the king. Campania also exported indigenous produce overseas and received foreign imports that were sold along with local goods at festivals. Southern Italy's other dioceses also prospered during Ostrogothic rule, including the grain fields of Apulia, the cattle industry of Calabria, and the swine industry of Lucania. Heavy shipping...
in the diocese of Istria entailed both cabotage and long-distance trade, with much of the commodity trade destined for Ravenna. Professional merchants, including those from foreign lands, also conducted trade in Ostrogothic Italy; for example, a Syrian named Antiochus resided in Naples, where he conducted a private shipping operation.

The scheduled taxation of Ostrogothic dioceses created regular shipments of goods to Ravenna for the maintenance and financing of the royal court, military operations, and other government functions. Some taxes were to be paid in kind which required an organization of the shipping of goods, similar in some respects to the *annona* system of the Empire. For example, Cassiodorus required a portion of the tax levy from Istria to be paid in wine, olive oil, and wheat. As these items had to be shipped across the Adriatic to Ravenna, he sent funds to Istria to offset the costs of not selling the goods on the open market and cover the shipping costs. Supplementing the shipping costs of in-kind levies was a prudent measure, one that benefited the Ostrogothic court through the maintenance of private merchant import and export trade in the goods and supplies desired by the court. Another example of court support for local traders occurred after a series of damaging raids by Anastasius (491-518). King Theodoric waived the taxes due from the city of Sipontum and suspended the collection of loans that were made to traders in order to keep shippers solvent.

Shipping was not only required for the regular taxation of the diocese, but for the supply of cities in times of crisis brought on by food shortages, natural disasters, or raiding activities. In such instances foodstuffs were often sent by ship for reasons of speed and expense. Such an instance was illustrated when Theodoric instructed shippers from the dioceses of Campania, Lucania, and Tuscia to commit to contracts with the wealthy guarantors of Gaul to deliver relief supplies. During one such period of food shortages, Theodoric promised the landholders of Arles continuous shipments of supplies would be sent from Ravenna to Liguria once the sailing season renewed. He also promised relief to Count Amabilis in Gaul, who was in desperate need of foodstuffs, with the shipments of supplies coordinated from multiple sources and structured within the contractual framework of local suppliers.

During the Ostrogothic period there was an interesting option in the Adriatic for moving goods by ship from the coast of Istria to the capital Ravenna. The shipping route from Istria was directly across the Adriatic to Ravenna and was not a difficult sailing route except in times of bad weather. When the

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50 Ibid., 8.31-33, 39; 12.24.
52 Cassiodorus, *Variae*, 12.22.
53 Ibid., 2.38.
54 Ibid., 2.20, 3.44, 4.5.
seas were not navigable, ships from Istria could use an alternate route that hugged the northern coast, moving through channels, and giving the appearance "as if they are moving through fields."\(^{55}\) The crews pulled the ships along with cables, keeping them level with ropes from shore.\(^{56}\) Towing was also utilized on the river systems. Since Ostia was by now out of use, ships that arrived to supply Ostrogothic Rome entered the harbor city of Portus, where they would unload their cargoes onto barges or store them in warehouses. These barges were pulled up the Tiber toward Rome by oxen, since rowing was particularly difficult against the current. The coast near Ravenna was protected by shoals and had no natural landings. Thus smaller boats were used in offloading cargoes from the large merchant ships, which then traveled up the Po River by timing their entrance with the high tide.\(^{57}\)

In northern Europe, the dominant Frankish kingdom was also engaged in a significant amount of waterborne trade, much of which was conducted overseas with North Africa and the Eastern Mediterranean as indicated by the amphoras, ARS wares, and coarsewares from sites in southern Gaul. The Franks also maintained an increasingly significant trade across the channel with the Anglo-Saxon kingdoms of Britain during the fifth to seventh centuries; and Anglo-Saxon objects have been excavated from sixth-century sites throughout Normandy and the Rhine areas.\(^{58}\) By the later sixth century the Frankish domination of Kent instigated a great flow of luxury items exported from the continent to Britain.\(^{59}\) Many Frankish gold coins dating to circa 595 through 625 have been recovered from the lower and upper Thames areas, and further northward dating to 625 and later.\(^{60}\) During the seventh century the Franks established formal trade agreements with the larger Anglo-Saxon kingdoms.\(^{61}\) These cross-channel connections are reflected in the excavation of balances and weight sets dating to the beginning of the seventh century and later, as well as in the pottery and glassware dating to after 625 excavated in Kent.\(^{62}\) The concentrations of balance pans and weight recovered from early Anglo-Saxon

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\(^{55}\) Ibid., 12.24.

\(^{56}\) Ibid.

\(^{57}\) Procopius, *History of the Wars*, 5.1.17-22, 5.26.10-13,17. Bends in the river, with their constant changes in wind direction, also rendered sailing difficult.


\(^{60}\) Arnold, *Anglo-Saxon Kingdoms*, pp. 56-59.


sites along the upper Thames and in Kent were possibly used for weighing gold coins and bullion of the Frankish and Byzantine standards, testifying to the strong trade contacts between them.63

**Shipping and Architecture**

Architectural projects in urban centers and fort construction along the borders also spurred the shipping industry. By the second century brick, cement, and timber were the primary materials used in urban construction. Timber was required for forms and braces in concrete and brick architecture, and for roof beams. Unlike cement and brick that could be produced near construction sites, timber had to be transported from limited source areas. Since the Republican period, sailing vessels had carried timber to Ostia and up the Tiber to fulfill the requirements of construction projects in Rome. This practice was continued well into the Later Empire.64 A second-century mosaic from Ostia depicts naviculari lignarii, merchants who frequently handled shipping of timber.65 Timber destined for a wide variety of construction projects was collected from forests all over the Mediterranean and Europe. Wooden roofs in basilica-style churches, for example, ensured the demand for massive timbers throughout Late Antiquity. However, there were difficulties associated with the shipment of timber, which was similar to those encountered in the transportation of stone. Timbers utilized for rafters and supports would often have to be carried as single large pieces. Vitruvius describes some of the difficulties entailed in this trade when a 120-foot long tree was transported to Rome. The weight of this piece of timber prohibited its transport up the Tiber, presumably due to the deep draft of the vessel.66

Throughout the Late Empire and Late Antiquity, timber was also shipped to supply the fuel demands of bath facilities in urban centers. By the first century the Italian forests were increasingly denuded, and timber was becoming scarce. By the third and fourth centuries, Imperial stipulations required that certain communities regularly contribute timber for use in metropolitan areas. By the end of the third/beginning of the fourth century, trading organizations were set up in overseas communities to ensure a regular contribution of logs for firewood. A prominent point of debarkation for timber was Terracina, where the salt contractors organized the timber trade and delivered wood to the baths.67

67 Although the change in burial custom from cremation to inhumation decreased the demand for timber, it was more than offset by the growing demand for timber to fuel the furnaces heating the increasing
Although the evidence clearly indicates individuals specializing in the shipping of timber, it is unclear to what extent this necessitated a specific ship design to accommodate a cargo of timber. It seems unlikely that specifically designed ships were required for timber transport, as merchantmen that carried architectural elements could also carry timber. The loading, stowage, and subsequent unloading of large logs would be analogous to the shipping of columns, and only in the most exceptional instances when extraordinarily large single logs were needed would special ships have been required. Timber was probably shipped as part of a mixed cargo along with salt, stone, and other building materials.

Numerous secular and religious buildings for the public, as well as private construction financed by aristocratic patrons, provided the demand for other exotic building materials. Marble, for example, was a highly prized stone utilized not only for support columns and exterior decoration, but also for interior furnishings. Large temples, baths, and basilicae were the hallmark of Late Imperial Roman cities and their construction a source of aristocratic prestige. From the fourth century onward church construction, predominantly financed by the state, dramatically increased at the expense of temple building and other secular projects. Under Zeno (474-475, 476-491) and Anastasius (491-518), the East was the focus of church construction and renewed imperial financing, with the Western kingdoms similarly active in the construction of churches. Marble was often the material of choice in church decoration and required regular shipments from the quarry sites to locations of construction throughout the Mediterranean and Europe. The early sixth-century Marzameni B shipwreck from Sicily, probably carrying architectural components destined for the church at Cyrenaica, provides a good illustration of this flourishing trade. Other marble objects that were often shipped were stone sarcophagi, which continued to be used into the fifth century throughout much of the Mediterranean and into the sixth century in isolated areas.

Marble suitable for construction and of sufficient aesthetic qualities to meet the tastes of both engineers and sponsors was found only in specific areas. Chart 68 lists the cargos and quarry sources of shipwrecks found carrying marble, much of which originated in the Aegean region, thus requiring long-distance shipping networks to reach associated construction sites. Recent investigation of the marble number of public baths: R. Meiggs, “The Timber Trade of the Roman Empire,” in The Seaborne Commerce of Ancient Rome: Studies in Archaeology and History, eds. J. H. D’Armo and E. C. Kopff, pp. 192-193.

70 Rodley, Byzantine Art, p. 30.
yards of Portus and Rome have shed new light on the marble trade. Fant convincingly argues that there was no marble surplus in the yards as has long been held, rather, remains found in the yards are rejects from a tremendous amount of volume moving through these facilities.\textsuperscript{71} A prominent example is the architectural materials for the construction of the S. Apollinare in Classe church (536-49) that were shipped from Imperial workshops in the Proconnesos region to Italy; these materials included marble revetments, pedestals, and capitals.\textsuperscript{72} Likewise, Libanius in a letter to Modestus refers to a \textit{decurion} who ordered the shipping of columns from Seleucia during the summer of 360.\textsuperscript{73} As a feature that conveyed opulence and grandeur, as well as an essential element in the basilica-style church construction of Late Antiquity, columns are the most prominent architectural pieces found associated with shipwreck sites of this period. Orders for marble were filled either through shipments from quarries or purchases from marble yards, or were scavenged from older buildings such as temples. Among many examples are the capitals in the nave of Theodoric's S. Apollinare Nuovo (completed circa 490) that were imported from earlier Roman buildings in Constantinople.\textsuperscript{74}

As a cargo marble was compact, sat low in the hold, and provided stability for a vessel. However, the significant weight and often cumbersome lengths of columns made loading and unloading difficult, with added propensity for hull damage. Ceiling planks would have been an essential component in providing proper protection for the inner hull and frames. The significant size and weight of marble components limited the total numbers of columns or other stone elements that could be shipped on a single voyage, thus increasing the transportation cost per item. Referring to Chart 68, the number of columns found on shipwreck sites varied from five to thirty-seven. This is contingent on the size of the columns and the weight of additional cargo carried, but a low number in any case. High shipping costs associated with architectural elements were a constant concern, as illustrated by a \textit{mechanicus} who could more cheaply transport columns to Rome by being hired by the Emperor and managed to include in the agreement payment to feed his people.\textsuperscript{75}

The successful overseas transportation of an unusually large cargo item illustrates the skill of shippers to adopt ship technology to accommodate heavy stone objects. As discussed in Chapter IV, Constantine financed the shipment of a large obelisk from Egypt to Rome via Portus for use in the \textit{circus

\textsuperscript{72} R. Krautheimer, \textit{Early Christian and Byzantine Architecture}, p. 278. Marble objects were typically rough-cut in order to reduce the shipping weight of the elements, and to save labor costs in cities.
\textsuperscript{73} Libanius, \textit{Letters}, 2.68.
\textsuperscript{74} Krautheimer, \textit{Byzantine Architecture}, p. 186.
\textsuperscript{75} Unfortunately it is not clear what this method was in detail: B. Baldwin, "Some Aspects of Roman and Byzantine Science," in \textit{Roman and Byzantine Papers 1989}, ed. B. Baldwin, p. 546.
maximus.\textsuperscript{76} As outlined in the previous chapter, a specially designed or modified vessel with a minimum length of thirty-five to forty meters would have been required to transport this obelisk from Egypt. One of the problems in stowing the large stone object was the necessity to place it central in the hull for reasons of maintaining ship stability.\textsuperscript{77} The presence of the mast or masts extending down through the center of the ship presented an obstacle to this manner of stowage. It is possible that the ship for overseas transport was of a sufficient length, at least fifty-five meters, such that it could accommodate the obelisk behind the mast. Such substantially-sized vessels are not supported by the archaeological evidence in the period of study; although as a special project ordered and financed by the Emperor a vessel specifically designed to transport this particular cargo was possible.\textsuperscript{78} Alternatively, the ship may have utilized a bipod mast formed by two timbers each extending from the bilge areas. This configuration has a long history in Egypt and presumably this ship would have been built, or at least outfitted, where the obelisk originated. The advantage of the bipod arrangement were that the obelisk could have been secured unimpeded beneath the masts and thus transported in a vessel that coincides with the upper end of sizes for Late Antiquity seagoing ships, of around thirty-five meters in length.

The construction and renovation of defensive works with durable materials also spurred the transportation of building materials and architectural elements. Changes in fort design maintained the demand for stone in the Late Empire throughout the border areas. Many forts were rebuilt and repaired in the early third century, and major defensive works were undertaken such as Hadrian’s wall in northern Britain. At the end of the third /beginning of the fourth century, new defensive strategies of Diocletian and Constantine required that border defenses delay major invasions until mobile reserve forces could arrive. This strategy influenced the architectural plans of the forts and other defensive works, as towers were frequently repositioned outside the walls, enhancing their defensive advantage by providing better firing angles. Walls were also thickened and the total number of gates reduced.\textsuperscript{79} Additionally, new forts were strategically located some distance behind the borders to further impede the progress of invaders.\textsuperscript{80} Extensive fort renovations, usually credited to Theodosius I (392-395), continued into the

\textsuperscript{76} Ammianus Marcellinus, \textit{The Later Roman Empire}, 17.4.12-15.
\textsuperscript{77} This would hold for either scenario of the obelisk being shipped in the hold or on the deck of the ship.
\textsuperscript{78} For example, the funding of an extremely large ship to ferry an obelisk from Egypt to Ostia by the Emperor Caligula: Pliny, \textit{Natural History}, 16.201.
\textsuperscript{79} Forts were thus able to hold out longer and tie up more enemy forces than before.
\textsuperscript{80} D. A. Weisby, \textit{The Roman Military Defence of the British Province in its Later Phases}, p. 6.
late fourth century, and the construction of hundreds of frontier fortresses in the earlier part of the sixth century are attributed to Justinian (527-565).81

Military construction taking place in the peripheral province of Britain provides a good illustration of materials transported for military construction. Forts built during the initial invasion and subsequent expansion were constructed primarily of earth and timber. However, by the end of the first and second centuries most of these forts were rebuilt in stone.82 After the invasion by Claudius in 43, large amounts of stone were brought into London for the construction of defensive walls, which alone required 35,000 cubic meters of stone, followed by materials for the construction of basilicas, a forum, baths, residences, an amphitheater, and the fort.83 After the second century, raiding in the territory of modern Wales instigated the construction of added Roman forts, notably at Caer Gybi and Cardiff, which were strategically located near quarries in order to benefit from the local transport of building materials. Forts that were located far from quarry sites transported stone at a much greater cost, with water transportation utilized whenever possible.

The third century also encompassed the construction of the Saxon Shore forts built along the southern and southeastern shores.84 This string of shore forts was further renovated and improved in the early and mid-fourth century.85 with additional forts being situated on the Germanic coasts at locations such as Oostvoorne, Brittenburg, and the mouth of the Scheldt.86 Coastal and riverine forts could be supplied by vessels such as the Blackfruits ship that carried twenty-six tons of ragstone. These rough-hewn stones were stowed in the bottom of the vessel, providing excellent ballast, and were situated atop ceiling planking that served to protect the inner timbers.87 The river barges that operated the lower

81 Although archaeological evidence indicates a somewhat reduced number, revealing that many were actually began earlier by Anastasius (491-518): Krausheir, Byzantine Architecture, pp. 156, 258.
82 Ibid., p. 5.
83 P. Marsden, Ships of the Port of London, pp. 82-83.
84 While the fort built at Reculver dates to circa 210-220, most of the other forts on the eastern shore date to the mid-third century. The forts receiving renovations under Septimius Severus included Ambleside, Bewcastle, Chester, Doncaster, High Rochester, Ilkley, Low Burrow Bridge, Malton, Manchester, South Shields, and York. Excavations indicate a particularly heavy period of construction in Britain between AD 296-305 under Constantius Chlorus: Welsby, Roman Military Defence, pp. 8-9, 69. Forts such as at Oudenburg on the continental shore of the North Sea were also begun at this time: S. Johnson, Roman Forts of the Saxon Shore, pp. 17-20.
85 These projects received little support from the continental provinces, themselves occupied with fort building and renovations in response to border incursions. P. A. Holder, The Roman Army in Britain, pp. 92-93.
87 Marsden, Port of London, pp. 80-84.
Rhine are thought to be larger than usual as a result of the demand created by Roman military complexes. These vessels were designed to meet the shipping obligations for building materials that supplied Roman forts and the growing vicini, or communities that typically arose around larger Roman forts.

There were typically eight legions stationed in forts and outposts along the German limita, inhabiting the larger forts such as those at Cologne, Mainz, Nijmegen, Birken Neuss, Strasbourg, Windisch, and Xanten. By the late third century, forts on the German limes were rebuilt with high walls and bastions to accommodate ballistae and bowmen. In particular, fort-building programs were undertaken by Probus (276-282) along the Rhine, in Switzerland, and along the Gallic coast. Civil structures also underwent defensive modifications in this period, blurring their differentiation with fort complexes. Forts were built and renovated in the Germanic provinces from the time of Emperors Julian to Valentinian, notably at Alzey, Boppard, and Koblenz. These were accompanied by a system of lightly fortified river crossing sites along the Rhine-Ille-Danube fronts.88

In addition to stone and timber supplies required for military construction, an adequate supply of roofing tiles was also essential. Often these tiles were manufactured at larger urban centers or legionary fortresses, from where they were shipped to civil or fort construction areas. For example roofing tiles with the stamp of one legion, the Legio VI Victrix, have been excavated from fort sites at Corbridge, Carrawburgh, Vindolanda, Chesters, Rudchester, Ecbchester, and High Rochester.89 Tile workshops at Dover are thought to have supplied the construction needs of the fleet.90 Tiles were often shipped significant distances overseas as illustrated by the Pudding-Pan Rock wreck off the coast of Kent that carried roofing tiles from Gaul in addition to its cargo of terra sigillata.91 Shipments of tiles were also transported throughout the Mediterranean. For example, the Capo Passero wreck found near Italy was carrying roof tiles as its primary cargo.92 From a purely practical standpoint, tiles were an easily manageable cargo, easily stacked low in a hull to ensure stability and minimum shifting.

Shipping and the Games

The gladiatorial arena throughout the Mediterranean and Europe provided a significant demand for exotic animals. The large numbers of surviving amphitheaters in nearly every province testify to the wide popularity of these games. Lions, tigers, antelopes, gazelles, leopards, bears, and boars were the most prominent among the animals used for shows. Although not always slaughtered, animals were

88 A. King, Roman Gaul and Germany, pp. 163-188.
89 Holder, Roman Army, pp. 94-95.
90 Johnson, Saxon Shore, p. 12.
91 Parker, Ancient Shipwrecks, pp. 343-344.
92 Ibid., p. 44.
sought in great numbers for single events or showings, and whereas municipal shows in smaller cities
had less lavish displays, they also sought the exotic species. Demand was met through shipping beasts
from their indigenous areas, where they were captured, to ports near the cities and their arenas.

Animal shipping was widespread because the source area for many of the commonly used
animals were quite distant from one another. Thus there was always a need for exotic imports regardless
of the location of a city. Africa provided lions, leopards, cheetahs, antelopes, and gazelles. Areas in the
Near East provided lions, leopards, and cheetahs, while tigers were found in India, Armenia, and the
South Caspian Sea region. Bears and deer were indigenous to areas all over Europe and parts of the
Eastern Mediterranean, and antelope inhabited the environs around the Black Sea. With such vast
geographical areas involved in the industry and so many types and numbers of animals demanded, both
ocean and river shipments were required.

Practical considerations of animal transport included the loading and proper stowage of the
animals, as well as adequate supplies of food and water to ensure their health during transport. It
appears from iconographic evidence, such as the Great Hunt mosaic from near Piazza Armerina in Sicily,
that large cats were transported in cages. The loading and transportation of cages would not have posed
an inordinate amount of difficulty, provided they were secured to prevent shifting and avoid injury to the
animals. When carrying predators a sufficient distance between cages would have been maintained to
promote calm and avoid injury to the animals. This space allowed the crew to maneuver between cages
and attend to the feeding and watering of the animals. It seems likely that ships with high length-to-
beam coefficients (less than or equal to 3:1) and of at least twenty meters in length would have been
necessary to provide adequate hold space. Ships of such proportions are common in the archaeological
record.

Special logistical concerns must have arisen when dealing with larger animals such as giraffes,
rhinoceri, or elephants, the only feasible manner of boarding being to have them walk under their own
volition. Aelian, writing around 200, described the loading of elephants onto ships by bringing them into
a shallow area near shore and erecting a bridge for them to cross to the ship. Each side of such a bridge
was lined with foliage in order to limit the animals’ vision and keep the elephants calm. On the ‘Great
Hunt mosaic’ there is a depiction of an elephant being loaded on board a ship using a ramp with similar

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93 In one such instance, Emperor Gordian was reported to have exhibited 100 *farae Libycae*, 1,000 bears,
200 British stags, 30 wild horses, 100 wild sheep, 10 elks, 100 Cypriot bulls, 300 ostriches, 30 wild
asses, 100 boars, 200 ibexes, and 200 gazelles: *Scriptores Historiae Augustae*, “Gordian III”, 3.6.7.
railings. Undoubtedly, difficulties escalated once these large beasts were on board and had to be stowed for the voyage. When ramps were used, the animals reached the ship at deck level and then descended another ramp leading into the hold. Given the immense size of these animals, standing as high as three and one-half meters, both the beam and hold depth must have been quite substantial, with a large amount of hold area necessary to keep these animals separated. Transport of the largest animals required the larger sized vessels of the period to accommodate them, vessels thirty meters and upwards in overall length. Even then, only a small number of the largest beasts could have been shipped per voyage, which contributed to the high costs for those sponsoring the games.

Shipping Administration

Ships, their routes, port facilities, and the offloading and loading of cargos were entirely or in part under the supervision of some imperial or kingly court authority. The Empire was directly involved in the construction and administration of merchant fleets to ensure the annona supply, and provided economic safeguards for private shippers. One primary area of control for any state authority in the period of study was the administration of port facilities. Claudius built the port just north of Ostia to ensure safe anchorage and that goods could be offloaded closer to Rome, thus decreasing the lighter and overland transport time and expense from ports further to the south. By the seventh century Portus was the largest dockyard in the vicinity of Rome, containing three harbors and a large number of grain warehouses. Since the sixth century BC, Carthage had been a busy harbor for merchant shipping and provided in addition a base for war fleets, a function that continued during the Vandal occupation. Stagnum was Carthage’s large harbor complex, possessing both rectangular and circular harbors, while Missua (Sidi Daoud) held the shipyards. This access to superb port facilities and large, productive shipyards instantly made the Vandals a significant economic and military power in the Mediterranean. Port construction and renovations took place with great frequency throughout the period in all coastal areas and are too numerous to detail in an overview. It is sufficient to state that port facilities had a potential for great sophistication, as at Caesarea, and often included such attributes as offices, warehouses, moles, and lighthouses.

Port administration was complex and required numerous officials due to the large number of facilities, the high volume of goods, and the administration of government tax levies. In Italy the offices

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95 Found at the Piazza Armerina villa, Sicily.
96 Olympiodorus, Works, 13.2.
97 Clover, Late Roman West, p. 7.
98 Caesarea had a pharos, as did Alexandria and Portus, which was a difficult harbor to approach and had a pharos erected by Cleopatra: Ammianus Marcellinus, The Later Roman Empire, 22.16.6-8.
of the procurator annonae, discussed above, were located at ports such as Portus and Puteoli, and played an important administrative role through the mid-third century and probably later. Additional bureaucratic offices in the Roman administration included the office of procuratores portus utriusque, in place from the time of Hadrian (117-138), that also dealt with overseeing port administration. Additionally, there was the office of procuratores pugillationes et ad naves vagas that monitored the destination of ships other than the Alexandrian fleet and dispatched Imperial communications. The administration under the procurator annonae also appears to have been extensive at Puteoli, with additional overseers such as the fiscus frumentarius and fiscus Alexandrinus, with the procurator portus also present until at least the second century. There are no surviving records from other ports that demonstrate such an extensive bureaucracy, but similar administrative structures undoubtedly existed at large important ports such as Portus, Alexandria, Carthage, and Caesarea. The direct involvement of the Vandal, Ostrogothic, and Frankish courts in shipping administration indicates that such bureaucratic systems would have been necessary to some degree in these kingdoms as well.

Utility Vessels

Utility vessels consisted of smaller craft that operated in riverine and coastal environments, typically utilized by private individuals for fishing and ferrying. Iconographic data rounds out the few archaeological examples discussed in chapter IV, providing ideas of activities associated with fishing vessels, such as pulling nets and hooking fish. While many of the iconographic examples illustrate the activities of fishing craft (probably the most common enterprise in which small utility boats were engaged) there are few written allusions to boats serving this task. Aelian referred to the practice of hanging lanterns from the prows of fishing boats, postulating that fish had no escape from the men that row and especially the men that rowed softly. Alciphron, also writing in the early third century, states that fishing boats were beached at the end of the work day, with most fisherman not having access to docking facilities, but instead pulling their craft on shore while they delivered their catch to market and returned home. There is reference to a fishing boat being used as collateral for a loan, suggesting that some fishing vessels must have had capital value. Most depictions convey small fishing vessels, usually decked with a storage area amidships, and operated by a crew of two to four men. The written

99 There were also specialized professions for the physical unloading of ships. The saccarii, for example, were the porters loading and unloading the sackloads of grain at a port. Houston, “The Administration of Italian Seaports,” pp. 157-163.

100 Aelian. On the Characteristic of Animals, 2.8.


102 Ibid., I.13. This was likely a larger fishing craft and probably not of the smaller types often seen in harbor and river depictions.
evidence indicates that schools of fish were a favorite target, gathered in by men working nets from small fore and aft decks.

Private individuals, taking advantage of riverine areas without nearby bridges, also operated ferryboats. Such ferries were operating over a wide geographical area, from Britain and northern Europe to the Near East. In one such example, Priscus reports that while traveling with Maximinus in the Balkans, they twice utilized Germanic ferries made from single logs. They observed in the course of their travels that the Germans were carrying rafts on their wagons to traverse the marshy areas around the rivers. Roman regulation did not overlook these operators, as ferryboats for Imperial use were kept on duty along parts of the Euphrates for transport across the river. Ammianus also mentions that Julian had issued orders to "the captains of the ferry-boats" operating between Chalcedon and Constantinople, further attesting to some official control.

*Containerization and the Economy*

It has been widely held that the economy of Late Antiquity had taken a drastic decline from that of the Roman Imperial period. There was undoubtedly some reduction in monetary purchasing power, in the production of the luxury-item industries, and in the overall amount of goods traded. However, the increasing number of excavated from Late Antiquity has shown that there continued to be large-scale architectural building projects, weapons production, agrarian production, and the shipment of large cargoes. However, it is the reduction in the size of ships and associated cargo shipments that have provided support for the hypothesized downturn in the Late Antiquity economy. As has been shown above, over the course of this period, vessels of a given length and length-to-beam ratio could carry more cargo than those of earlier periods due to both lighter hulls and more box-like cross-sectional shapes. In addition to changes in ship construction, amphoras used in shipping during Late Antiquity were also undergoing modifications.

Forty examples of amphoras from the second through seventh century were modeled in order to obtain the average estimated volumes of the amphora fabric and their average estimated capacity. Chart 70 outlines the primary data for these amphoras, including their probable contents. In order to

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105 Ibid., 22.16.2-3.
estimate the changes in amphora efficiency (capacity / fabric volume) over time, the values were averaged for amphoras used in a given century. The resulting figures demonstrate a clear increase in the efficiency of amphoras over time for all amphora types that were used in the analysis, and an even greater increase in efficiency when types with extremely limited ranges or utilized in small numbers are excluded from the average (Chart 71).\footnote{108} There was a good sample of wine amphoras for each century, and the evidence is clear for an increasing trend over time, especially for those that were most commonly shipped (Chart 72). Grouping the amphoras into three types by probable contents, one notes similar trends for those types carrying fish sauces (Chart 73).\footnote{109} Information is scarce for the amphoras types carrying olive oil, especially for the fifth through seventh centuries, thus a trend is not clear for these types after the fourth century (Chart 73).\footnote{110}

However, in a comparison of trends for all three types of contents (Chart 73) it is apparent that amphoras carrying fish sauces experienced the greatest increase in efficiency, and those carrying olive oil were apparently already more efficient than the amphora carrying other types during the period from second to fourth centuries, and possibly even later.

An increase in the efficiency of amphoras translated into shipping of more contents in relation to container weight over a given period. Thus, more product could be shipped in a given hold space filled with seventh-century amphoras than one containing second-century amphoras or, by extension, a fifty-ton cargo of the seventh century would have delivered more product than a fifty-ton cargo of the second century. Taking the increasing amphoras efficiency into account, coupled with the associated changes in hull weight and shape, vessels from later in the period could have held more amphoras than a vessel of similar length and beam from earlier in the period. Moreover these amphoras would have contained more product. Hence, the reduction in sizes of merchantmen from the second through seventh centuries may not necessarily indicate as drastic a decrease in the amount of actual goods being shipped in Late Antiquity as is generally supposed.\footnote{111}

\footnote{108} Those excluded from the most commonly shipped types were the Egyptian products that had an exceptionally small distribution and the Spathia type, found only in small numbers on shipwrecks.\footnote{109} The contents of the Richborough 527, spathia, and Late Roman 3 types remain uncertain, hence their exclusion from the graphs showing contents.\footnote{110} For example there were only two representative types from the fifth century.\footnote{111} Other factors also would have played an important role in the reduction of merchantman sizes over the period under study, including the reduction of risk in waters now plied by ships of warring states and pirates, where speed was also a concern.
CHAPTER VI
THE SOCIO-POLITICAL RÔLES OF MILITARY VESSELS

Introduction

At the beginning of the second century the Mediterranean, western, central, and northern European regions were under Roman Imperial dominion, and protected through a vast military. Invaders originating from eastern Europe and the Asian steppes soon challenged this dominance. By the third and fourth centuries, Germanic and Scythian groups were pressing on the borders of the northern provinces and penetrating Roman territory in central and western Europe. Their aggression was not limited to terrestrial operations, and they soon developed naval power, initially exercised in the North and Baltic Seas, but soon active in the Mediterranean as well. The incursions from land and sea forced the Empire to allow some groups to settle on provincial territories during the fifth and sixth centuries, while still others forcibly took lands. This loss of land eroded the Empire’s economic-base, and consequently its ability to maintain an effective military resistance to incursions, forever altered the socio-political landscape of the Mediterranean and Europe.

New states were carved out of lands previously controlled by the Empire and ruled by its long-time Scythian and Germanic enemies such as the Vandals, Visigoths, Ostrogoths, and Franks. These newly formed courts lorded over lands inhabited by some who were familiar with warship technology, industries associated with warfare at sea, and, in all probability, tactics of warfare as well. By utilizing the skills and technologies of its new subjects, all of these states successfully maintained and advanced the development and applications of naval technology for warfare in their kingdoms to varying degrees. Vandalic North Africa, Visigothic Spain, Ostrogothic Italy, and Frankish Gaul all enjoyed flourishing economic growth in large part through successful overseas trading ventures. A strong naval presence was crucial in maintaining this trade, in establishing sovereignty in the face of the still-formidable Roman Empire, and competing economically and politically with the other kingdoms. As a result, the Empire was now faced with rivals at sea who threatened both its trading routes and territorial possessions. The successful application of ship technology in military operations was therefore paramount in ensuring the ultimate success of the Empire and the newly formed kingdoms.

The Roman Empire

The nature of war fleets

"The Romans seem to have regarded naval warfare as an extension of land warfare, not as a branch of service in its own right." 1 Although there were similarities in the types of weaponry utilized

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1 II. Elton, Warfare in Roman Europe AD 350-425, p. 257.
on land and at sea, it is an oversimplification, and somewhat misleading, to characterize the Roman navy as merely an undifferentiated extension of terrestrial forces. For purely operational and organizational purposes, many of the naval offices, posts, and terms were similar to, if not the same as, those inherent in terrestrial-based forces. Fleets accompanying armies on campaign were loosely organized in the fashion of a camp and departed and anchored in set arrangements. However, much of the practical aspects of operating and maintaining ships, as well as tactical and strategic concerns, were not equivalent to those in land operations.

Much of the written evidence for military applications of ship technology centers on its use in supporting land operations. The foundation of the Empire’s naval forces began in earnest with the ascension of Augustus, and within one hundred and fifty years the Romans were the unquestionable masters of the North and Mediterranean Seas.\(^2\) It has been assumed by scholars that the navy was significantly weakened to the point of virtual demise by the fourth century due to a lack of any significant opposing navies, which required the fleet’s maintenance and to the general decline of Roman fortunes.\(^3\) Such arguments are based on a misunderstanding of the military situation during the third through fifth centuries and run contrary to the evidence for fleet maintenance and operations during the Late Empire and into Late Antiquity. Even without the naval threat of an organized enemy force during the Late Empire, a naval presence was necessary to discourage such naval opposition from arising. Through dominating the trade routes with flourishing port cities, the Empire enjoyed economic advantages that were too important to jeopardize. Thus, the deterring of piracy and raiding necessitated the Roman military to maintain a sufficiently strong naval presence. Large-scale and organized sea battles also occurred periodically during the civil wars of the third and fourth centuries, which, in turn, served as incentives to further develop warship technology and battle tactics. Fleets used in civil wars were raised in haste for immediate deployment and were independent of a larger military strategy. These civil war fleets were reported to have been very large, as in Constantine’s (307-337) campaign against his rival Licinius in 323/324, where the former’s navy boasted two hundred warships.\(^4\) Whether or not these numbers were exaggerated, the rapid construction of a fleet necessitates the survival of warship construction technical know-how, a nucleus of warships already in service to serve as models and for training, and the presence of active shipyards and port facilities for their production.

\(^2\) Starr argues that Augustus formed a permanent navy as a result of his personal military experiences and the understanding of its strategic need. Furthermore, the navy was maintained by successive emperors due to their conservative nature and ability to easily afford the expenses: C. Starr, *The Influence of Sea Power on Ancient History*, pp. 72-73.

\(^3\) Ibid., pp. 78-81.

The number of standing fleet squadrons had apparently decreased by the reign of Diocletian (284-305) from what it had been half a century earlier. However, later accounts indicate that the Romans remained capable of marshalling substantial naval forces during the Late Empire and Late Antiquity. Orosius described a fleet consisted of three thousand seven hundred ships commanded by general Heraclianus in an expedition from Italy to Africa, and in 468 Leo (457-474) raised a large fleet from all over the eastern Mediterranean and sent it under the commands of generals Basiliscus and Heracleius to North Africa. Priscus puts the size of this later fleet at one thousand ships, and Procopius adds that one hundred thousand men were raised and sent on transports. Although a critical analysis of these passages would suggest some exaggeration in the actual numbers of vessels included in the fleets, they do bear witness to both the existence and active operation of fleets into the fifth century.

Specific references and events have been used to support the depiction of a weakened Roman navy after the second century. A tenuous account of Frankish mercenaries commandeering ships from a Roman fleet in the 280s is foremost among them. If the Franks indeed hijacked ships from a Roman fleet, it does not necessarily suggest Roman naval weakness. The captured ships were not necessarily warships, but could have consisted of a few sailed transports that the Franks stumbled upon in a small port. It also does not indicate weakness if a few ships making a run for the straits might have escaped detection. Faced with raiding in North Africa, the Black Sea, Britain, the northern shores of Gaul and Belgica, and the maintenance of the annona from Carthage and Alexandria, the Roman navy was in all probability spread thin, but it continued its with mission. That Imperial ships were stationed in Thrace along with the other areas known to possess fleets is indicative in itself of a considerable Roman presence.

Constantius' (305-306) cross-channel campaign is also utilized as an illustration of diluted Roman naval power. Three years had been required to ready his invasion forces, the time consuming element having been the difficult preparation and logistics of amassing suitable land forces. Ships could have easily been collected, constructed, or pressed into service for the crossing in less than a year, but gathering an adequate number of sufficiently trained troops to successfully carry out the battle required additional time. Hence the difficulties associated with his planned overseas invasion of Britain were not necessarily indicative of a diminished Roman fleet at the beginning of the fourth century, but more telling of a strained supply of adequately trained fighting men in the Empire.

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5 Orosius, *The Seven Books of History against the Pagans*, 7.42.13.
7 Nazarius, *Panegyric to Constantine Chlorus*, 18.3.
8 His reliance on Frankish mercenaries support the proposition that he lacked enough trained personnel: P. Salway, *Roman Britain*, pp. 304-310.
That Vandal sea raids were perpetual during the fifth century, and have traditionally been cited as evidence for a somewhat diminished Roman naval capability, particularly insofar as the vulnerability of the Italian peninsula was concerned. In addition to the territorial losses in North Africa in 439, the Empire also forfeited numerous fleet ships that had been stationed in Carthage. The Empire incurred further setbacks with the loss of the Italian fleet bases to the usurper Odovacer in 476, only thirty-seven years after the Vandals had seized Carthage. Thus it was only between the period 439 to 476 that the Romans had the strategic necessity or responsibility to defend Italy. However, these events do not necessarily themselves indicate Roman naval weakness as other military demands were more imperative during these thirty-seven years. For example, in the 440s, the Empire was confronted by Hunnic invasions from the East and beset by a plethora of German and Scythian groups instigated through the Hunnic advance, most notably the Franks, Alamanni, Burgundians, Angles, Saxons, and Gothic amalgamations. The Roman fleet stationed in Sicily during the campaign against Gaiseric in 441 was consequently recalled to deal with Attila, so that making a treaty with the Vandals became necessary. Although the Huns were dealt with by the mid 450s, the Goths proved to be a particularly persistent problem for the eastern portion of the Empire throughout the 460s and 470s. Thus, during this period of Vandalic raiding on Italy while still under Roman control between 439 and 476, the Empire was forced to divert significant resources to troubles along their eastern and northern borders. The victory by the Vandals in 468 was a major setback to the Romans, and before they could affect a full recovery, Italy, their last hold in the West, was effectively lost within eight years. Although Priscus suggests that only a single fleet could be spared for Western operations at this time, that the Empire was able to mount large-scale military expeditions to North Africa in 442, 468, and 470 that, in fact, attest to its significant military naval capabilities during this period.

Undeniably, the loss of naval assets in North Africa and Italy, combined with a diminished economic base resulting from the loss of agricultural lands, impaired the Empire’s ability to conduct and maintain large-scale campaigns. However, it is undeniable that the fleets were never abandoned and they continued to constitute a vital military asset in the Late Empire and Late Antiquity. Moreover, the fleets became even more crucial at a time when many coastal lands and their interiors were no longer under Roman dominion, and Roma attacks by sea consequently became necessary more often. Interestingly, artists maintained their propensity for depicting seagoing warships between circa 50 and 450, a practice

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9 Priscus, Works, 9.4.
10 Ibid.
11 R. Collins, Early Medieval Europe: 300-1000, p. 117; A. H. M. Jones, The Later Roman Empire: 284-602, pp. 221-224. The Vandals posed a threat, not encountered by the Romans for centuries, of an opposing fleet to which adjustment required time.
that also suggests a significant continued naval presence. There was, in addition to sea operations, an increased emphasis on riverine exercises from the third to the beginning of the fifth century. Escalated patrols along the Rhine and Danube rivers necessitated an increased investment in military vessels capable of negotiating shallow inland waterways, and a further increase in the size and variety of military vessels comprising the fleets.

Another popular misconception is that the Imperial fleets were comprised almost exclusively of warships. Large fleets consisting only of warships were unnecessary in the absence of potential for full-scale strategic warfare involving one fleet against another. Mediterranean fleets of the second through fourth centuries were primarily required in a logistical capacity to transport food, supplies, and military personnel among the provinces during campaigns. Priscus refers to three hundred ships requisitioned in 362, suggesting that private transports were sometimes pressed into service. It is doubtful that a large number of warships would have been in private employ of individuals or local magnates. A small number of warships were required to protect transports from pirate attacks and for assisting in military operations along coastal areas.

As discussed in Chapter IV, the iconographic evidence suggests that warships were decreasing in size and that fewer officials were utilizing them for travel by circa 250. This would be consistent with the fact that the duties of fleets were primarily involved with logistics, thus necessitating their compositions to be a mixture of predominately transport vessels with fewer warships that were smaller than those of the Republic and early Empire. Oared warships operating in concert with Emperor Caracalla’s sailing transport indicate such a mixed composition of ships within fleets. Similarly, Julian’s fleet in 363 consisted of a high percentage of transports. It seems likely that more vulnerable regions, such as the shores of Britain and northern Gaul, where raiding was more prevalent, would have necessitated fleets with a somewhat higher representation of warship and patrol vessels than in unthreatened areas. Warships were instrumental in providing protection for the military supply vessels. For example, the classis Britannica was responsible for the transportation of troops, equipment, and supplies required in Britain, and maintained warship patrols. Such responsibilities undoubtedly necessitated a variety of vessels within the composition of the fleet. While numerous merchant or transport vessels were needed to fulfill these transportation requirements, warships were requisite for the protection of transports and interception of raiding parties along the Britain’s southern and eastern coasts. Patrol vessels also served on scouting operations to forewarn forces of potential attack. Ninety-

two warships readied “for sea fighting” protected the transports in Leo’s fleet; these warships being single-banked dromons with covered decks to protect the rowers. Later in 508, Emperor Anastasius commissioned an expedition to Italy where eight thousand troops traveled on one hundred transport ships accompanied by one hundred oared galleys.

Fleets and bases

As part of the organization of naval forces, bases for fleets were established in order to train, outfit, and repair the ships. Many of these headquarters also organized scouting and escort patrols, and thus were established near areas of unrest. Due to strategic and geographical necessities, the fleet bases shifted their locations from the third to seventh centuries. The two major bases in Italy from the first through third centuries were located at Misenum and Ravenna, out of which the classis Misenensis and the classis Ravennas operated respectively. Also during this period, the classis Africanus operated out of the large port facilities in Carthage and the classis Britannica was stationed along several ports on the southern and southeastern coasts of Britain and northern coast of Gaul. Tile stamps found at Lympne suggest this was a possible headquarters for the classis Britannica during the first and second centuries, with Richborough and Dover also serving as principle harbors. Primary among the classis Britannica ports located on the northern coast of Gaul were probably Boulogne and Gesoricum, the latter being where Carausius set up command of the fleet. The classis Pontica, originally stationed at Trapezus, moved to Cyzicus in the later second century to better guard the Hellespont. The classis Moesica, whose ships may be those depicted on Trajan’s column, was stationed at Tomis. By the beginning of the fifth century, the fleets of the North Sea and the lower Germanica were abandoned, leaving only the major fleet bases located at the ports of Carthage, Aquileia, Como, Ravenna, Misenum, Arles, the mouth of Somme, and Alexandria.

River fleets

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18 G. Webster, The Roman Imperial Army, p. 159.
19 Ibid., p. 160. In conjunction with the construction of the Saxon Shore forts in the late third century, Dover became the principle base and possible later headquarters of the classis Britannica. At this time Portchester began to fall out of use, with the garrison moving from Portchester to Bitterne, although some scholars interpret the fort at Bitterne as an addition to the defense network and not a replacement of Portchester: J. Johnson, The Roman Forts of the Saxon Shore, p. 62.
20 Constantine crossed from Britain to Boulogne in Gaul after being proclaimed Emperor: Olympiodorus, Works, 13.2.
21 Guard posts at the eastern end of the Black Sea were undoubtedly under the authority of the classis Pontica as well: Starr, Sea Power, p. 77.
22 Ibid., pp. 67-81.
A variety of vessel type seems to have characterized river fleets in addition to their seagoing counterparts. Maurice differentiates the boats utilized in river operations as fighting ships, 'other' ships, supply ships, and smaller boats.23 The *classis Germanica*, *classis Pannonica*, and *classis Moesica* consisted entirely, or in large part, of river vessels; the *classis Britannica* probably contained some river vessels as well. The *classis Germanica* and *classis Pannonica*, which patrolled the Rhine and Danube rivers respectively, appear to have been comprised almost exclusively of river vessels, and had their own commanders.24 Both the *classis Pannonica* and *classis Moesica* were responsible for securing the Danube, and the early ship types from these fleets are represented by the early second-century Oberstimm vessels, possibly of the same type used by the *classis Germanica* at this time.25 The vessels of the *classis Germanica* and *classis Pannonia* in the late fourth century probably resembled those excavated near Mainz, Germany.26 Along with the Rhine territories in which they operated, these river fleets succumbed to the Germanic and Scythian invaders by the beginning of the fifth century.

The Danubian fleets continued operations into the fourth century, albeit considerably overextended, and thus required that local vessels be pressed into service by commanders on campaigns. In one such instance, Julian (361-363) ordered the 'rounding up' of indigenous boats while on campaign along the Danube in 358 to ferry his forces across the river; such a conscription suggests that Julian did not have access to boats from the river fleet.27 Subsequently, when pushing through Raetia en route to Italy, Julian was forced to cross rivers using boats that he "luckily" found in large numbers nearby.28 Their overtaxed circumstances notwithstanding, flotillas continued their operations on the Danube into the early fifth century.29 In fact, they were strengthened along the middle and lower Danube around 412.30 Both in military operations and in the maintenance of trading networks with the interior, river patrols continued to be indispensable. Concerned with the shipment of supplies from the Baltic countryside to Imperial markets, Maurice emphasized the ease and utility of using boats on the Danube.

24 One such individual was Pertinax, who supervised operations of the German fleet. Pertinax, "Julius Capitolinus," *Lives of the Later Caesars*, 1.6-2.1.
26 Although Höckman does not feel these particular craft were actually in service of the *classis Germanica*, they were undoubtedly similar in many respects, if not identical, to those of the fleet operating to the south: O. Höckman, "Late Roman River Craft from Mainz, Germany," in *Local Boats: Fourth International Symposium on Boat and Ship Archaeology*, Porto 1985, ed. O. Filgueiras, p. 25.
27 The enemy was reported to have been fooled by the native appearance of the boats when the Romans were approaching for an attack: Ammianus Marcellinus, *The Later Roman Empire*, 17.13.12-18.
28 Ibid., 21.9.1.
29 *Codex Theodosianus*, 7.17.1; *Notitia Dignitatum*, 32.50-52, 55-56, 33.58, 34.26-28, 37, 40, 42-43.
30 *Codex Theodosianus*, 7.17.1, 16.2.
and its tributaries for transport in the late sixth century. River fleets were also used as a baggage train for the army when possible. Julian, while moving along the course of the Euphrates, rendezvoused with his river fleet that consisted of fifty warships and one thousand transport vessels carrying food, weapons, siege engines, and fifty pontoons for building bridges. This river fleet was to shadow the Imperial army, and carry the supplies and provisions as the campaign penetrated deep into Assyria. Once Julian was forced to turn away from the river in pursuit of Persian forces, he ordered the fleet burned to prevent it from falling into Persian hands. However, he first removed twelve small boats to be carried by wagons for use as bridges. The practice of transporting boats by wagon was not a novel one, having been undertaken by Trajan while on his campaign in Mesopotamia.

With the Rhine and Danube demarcating the effective border of the Empire in Europe, river fleets were an increasingly important component of the military in the third through fifth centuries. As early as the first century BCE, the Roman military was utilizing river systems such as the Danube to transport supplies and equipment. Recognizing the strategic importance of river fleets, military leaders ensured their use during campaigns in enemy territories. However, not all stretches of river systems were available for patrolling by river craft, for treacherous rapids prevented navigation on portions of the Rhine. Seasonal variation in the riverine environments often made navigation difficult. In the winter, vessel usage was limited by the encroaching ice that could trap and render boats inoperable.

River fleets proved particularly useful in the military exploits of the fourth century, as patrol boats were essential in alerting the army to raids across the rivers at borders vulnerable to attack, as in the case of Germanic groups using dugout canoes to attack Illyricum. The importance of river fleets to Roman defense is also illustrated by their absence, as in 376, when a cessation in patrolling operations along the Danube allowed the Greuthungi to cross in rafts and pillage Roman territory. River fleets also enabled preemptive strikes on enemies amassing along the borders. During a campaign in 357, Roman troops on small boats were able to reach an island in the middle of the Danube held by the

31 Maurice, Strategicus, 11.4.
32 Ibid., 23. 3.8; 24.1.4, 7.2-6. He also now had at his disposal around 20,000 men freed from their towing and maneuvering duties. It must be considered that the figures of 1,000 river transports operated by 20,000 men are and exaggeration. Nevertheless, the average of 20 men per ship, although a little high for practicality is still within reason.
33 Zosimus, New History, 3.5.2; Dio Cassius, The Roman History, 68.26.1-4. Julian is reported to have used over 600 vessels in this campaign, although we can logically assume this to be an exaggeration.
34 Vegetius, Epitoma rei militaris, 4.37.
35 Strabo, Geography, 7.3.13.
36 Ammianus Marcellinus, The Later Roman Empire, 15.4.
39 Ibid., 31.5.2-3.
Alamanni and steal the enemy's "rickety" watercraft. Afterward eight hundred troops were dispatched upstream in "small, swift boats" in a flanking movement that allowed them to seize the island.\(^{40}\)

**Seagoing fleets**

While the archaeological evidence from the Mainz and Oberstimm sites, supplemented by iconographic evidence, provides a good chronological outline of river warships, having iconographic evidence alone for seagoing warships allows for only tentative conclusions. As discussed in Chapter IV, iconographic evidence for Late Imperial warships appears to indicate large, highly decorated vessels, many of which were depicted with imperial standards. Most Late Imperial warships were depicted with ten odd oars per side. Given that the number of oars is likely under-represented, this indicates warships of around eighteen to twenty meters in length (Chart 52). By the fifth century, the ship-of-the-line in the Roman navy was the dromon (or "racer"), a swift single-banked warship with a full fighting deck that also served to reduce the chance "of rowers being hit by enemy missiles".\(^{41}\) Priscus' description of eleven rowers per side for these warships in the fifth century suggests they were smaller vessels of approximately fifteen meters in length. Iconographic evidence also substantiates the smaller size of vessels after the mid-third century, as the total number of oars represented on illustrations decreases (Chart 52). Such smaller vessels support the hypothesis that warships were decreasing in size from those of the second/third centuries. Smaller ships would have been both swift and maneuverable features that correspond well with the two primary characteristics of the dromon.\(^{42}\)

During the defeat of the Roman fleet in 470 by the Vandals, the Roman general John stood on the deck of his ship, moved himself from side-to-side, and fought the Vandal vessels which had surrounded his own.\(^{43}\) From such accounts it appears that decks spanned the width of at least some portions of the hull and possibly over its entirety. Rowers sitting under a full deck would have been protected from projectile fire and also hidden from view. This may explain their consistent lack of representation in iconography. Dromons were apparently capable of being deployed during the winter months, typically a time of turbulent seas in the Mediterranean.\(^{44}\) Winter deployment was probably necessitated by the increased threats at sea from the third century onwards. This expanded time of operation, possibly to year-round duty, created new demands on warship design and maintenance. In order to achieve decent stability in the rougher winter seas, these ships must have had suitable length-to-beam coefficients and drafts, with adequate freeboard below the levels of oar ports to prevent flooding.

\(^{40}\) Ibid., 16.11.6-10, 17.1.3-4.
\(^{41}\) Procopius, *History of the Wars*, 1.2.15-16; 3.11.14-16.
\(^{43}\) Procopius, *History of the Wars*, 3.6.23.
\(^{44}\) Maurice, *Strategicon*, 11.4.
Single-banked ships could afford a greater amount of freeboard than multi-banked ships, and must have been favored in the shift towards year-round operations. This was possibly a determining factor in the exclusiveness of single-banked warships in the Late Empire and Late Antiquity. Ships with length-to-beam coefficients under approximately 6-7:1 could have feasibly operated in rougher winter seas without the significant risk of capsizing that longer and narrower vessels would have experienced. If warship construction paralleled that of merchantmen, the reduction in the size and increase in spacing of mortise-and-tenon joints would have facilitated repairs to most areas of the hull, particularly if operating year-round. Furthermore, a reduction in the use of the water-line ram would have lessened the necessity for the dispersion of force throughout the hull effectuated by mortise-and-tenon joints.\textsuperscript{45} These changing construction techniques, along with producing smaller warships, would have kept timber and labor costs under control.

Scholars have argued that warships were limited in their operational range, and consequently in their duties. For instance Starr maintained warships had a two-hundred-mile limit before it became necessary to return to land for provisioning, a constraint that rendered them unsuitable for the overseas protection of transport vessels.\textsuperscript{46} This circumscribed range is incompatible with the structural features of warships and their reported roles during the Late Empire and Late Antiquity. Proponents of this limited warship range usually base their arguments on the constraints of oared propulsion, and have not considered the overwhelming evidence for the use of sails by warships, such as the sixth-century warships that Procopius’ stated were “sailing swiftly.”\textsuperscript{47} Justinian’s fleet of warships and transports on campaign in Africa against the Vandals also demonstrates the use of sail. While shadowing the land forces along the coast, his fleet encountered difficult navigation problems due to wind directions and shallows. In dealing with these problems, ships adjusted the size of their sails as were required by the changing winds and their proximity to shore.\textsuperscript{48} As outlined in Chapter IV, nearly half of warship illustrations between circa 50 and 450 were depicted with sails. This would have provided sufficient propulsion to relieve rowers from continually working on journeys. Hence, overseas campaigns and escort duties were more than feasible. Furthermore, transports under escort carried provisions, that could have supplied warship crews thereby limiting the need to land for provisioning. If, by Late Antiquity, warships were built with lower length-to-beam coefficients, there would have also been increased hold space for carrying supplies, in particular water, for the rowers.

\textsuperscript{45} Personal communication with Dr. Frederick H. van Doorninck, Jr., July, 2001.
\textsuperscript{46} Starr, \textit{Sea Power}, p. 73.
\textsuperscript{47} Procopius, \textit{History of the Wars}, 1.2.15-16, 3.11.14-16.
\textsuperscript{48} Ibid., 3.18.5; 4.8.6-7.
Despite a lack of multi-banked vessels in the Late Empire and Late Antiquity, authors of the period continued to use terms identical to those that described the multi-level warships of earlier centuries. The lack of a definitive typology and associated terminology is a primary source of confusion in discussing warships of Late Antiquity. Inscription and literary evidence specifies four ship types within the Imperial Roman navy: the liburnian, trireme, quadrireme, and quinquereme. The term 'trireme' is one of the most frequently used terms and appears, for instance, in the report of Caracalla where after the foundering of his ship, Caracalla transferred to a trireme to continue his journey from Thrace to Asia. Scholars have assumed the term 'trireme' to designate a vessel having three banks of oars in Late Antiquity, similar in arrangement to the Greek 'trireme' warships of seven hundred years earlier that are hypothesized to have had three banks of oars.

Certainly, by the Late Empire the term 'trireme' could not have referred to three-banked warships. The overwhelming majority of available evidence supports warships possessing a single bank of oars during this period. Dated representations on coins provide a particularly strong evidence for warship types, and the overwhelming numbers of them shown with a single bank of oars. Casson argues that because these single-banked vessels were most often depicted, and that since only the most prestigious and powerful ships were represented on coins, these ships were thus the largest and most powerful vessels in the Roman fleet, even larger and more powerful than triremes. This argument assumes that triremes were three-banked warships in this period, and that single-bank warships were of considerably larger size. However, why build three-banked triremes if single-banked ships-of-the-line were more powerful? It would have been a waste of ever diminishing resources to continue building militarily less utilitarian or formidable three-banked vessels that tied up larger numbers of troops and required difficult training, if single-banked vessels were tactically and economically better suited, to warfare of the era. Furthermore, if three-banked triremes were the most common ship of the fleet, it requires explanation as to why artists never depicted them over such an extended period of time in other mediums. A simpler solution to the understanding of single-banked warship depictions on coins and in other mediums is that these vessels indeed represented triremes and liburnia of the Roman Imperial fleets from the second through seventh centuries. This would also explain why artists depicted single-banked warships almost exclusively, as there were no multi-banked warships in service.

Written evidence from as early as the first century indicates a lack of correlation between the

49 L. Casson, Ships and Seamen in the Ancient World, p. 156. There is a 'six' mentioned once as a flagship, but this vessel was not considered a standard operating galley in the navy.
50 Aelius Spartanus, “Antoninus Caracallas,” 5.1-6.5.
51 Elton, Warfare in Roman Europe, p. 98.
52 Casson, Ships and Seamen, p. 156.
term ‘trireme’ and a three-banked warship. Tacitus reports *triremes* operating on the Rhine and its tributaries as part of the *classis Germanica* in the first century.\(^{53}\) Assuming his correct use of the term, this would suggest that *triremes* were not three-banked vessels, but instead the single-banked vessels found in the

iconographic evidence. A three-banked vessel would have been too large, cumbersome, and deep-drafted to have operated effectively on the Rhine, and particularly in its shallower tributaries. Tacitus also refers to a *trireme* that was appropriated by a group of Germanic warriors (*Canninefates*) and maneuvered up a tributary of the Rhine. Again, there is the dilemma of reconciling how a very large and deep-drafted vessel operated in relatively shallow and winding river branches. It also seems unlikely that a group of unpracticed Germanic warriors had the ability to coordinate the rowing of a three-banked vessel, a feat that Hellenistic scholars argue required considerable training. Conversely, many Germanic groups were familiar with single-banked seagoing vessels and would plausibly have been able to accomplish the rowing of such a ship.

As warships were overwhelmingly represented with a single bank of oars, the differentiation in terminology applied to ships such as the *liburnia* and *trireme*, must be based on features other than the number of oar banks. Thus, by extension, it is logical to deduce that the terms *quadrireme* and *quinquereme* also have nothing to do with the number of rowing levels, as the existence of four- and five-banked vessels becomes ludicrous. It is both inconsistent and illogical to argue for a system of naming with numerical prefixes (‘mono-’, ‘bi-’, and ‘tri-’) that related to the number of oar banks, but had no relation to oar banks from ‘quadri-’ upwards, although this is a commonly held position for the Hellenistic period. Considering that these incremental prefixes were possibly related in a particular system, and that they were not a reference to the number of rowing levels, one must consider the association of alternative features with these terms.

Another argument for the use of the term ‘trireme’ focuses on the number of men per oar. This is relevant to the Late Empire and Late Antiquity, as oars manned by multiple oarsmen was indeed practiced by the ninth-century, as well as in the Hellenistic period. Byzantine dromons had two hundred oarsmen manning two banks of oars, one hundred and fifty above and fifty below. Certainly, there could not have been a single individual per oar, since that would have resulted in a vessel of over 160 meters in length; rather, there were several men to an oar at least on the upper bank. As discussed in Chapter IV, the range of total rowers mentioned in written accounts during the period under study ranged from 20 - 50. If Priscus’ observation of 11 oarsmen per side of a warship actually referred to 11 oar stations per side, two men per oar would result in a total of 44 oarsmen and fall within this range. Thus a *trireme*

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\(^{53}\) Tacitus, *The History*, 4.16, 79; 5.22, 23.
may have had three men per oar (a total of 66 oarsmen), a quadrere me four men per oar (a total of 88 oarsmen), and a quinquereme five men per oar (a total of 110 oarsmen). Each of these vessels would have totals outside the range, but that in itself does not preclude them from having existed. The lower length-to-beam coefficients for warships of the period would have provided the increased beam necessary for additional men per oar. However, several construction problems remain in accommodating four to five men per oar on warships, especially considering the smaller dimensions of warships likely common to Late Antiquity. Furthermore, there are no explicit references for multiple rowers per oar. Therefore, these difficulties suggest that these terms did not refer to either the number of oar levels on a vessel or the number of oarsmen per oar.

Another hypothesis is that these designations referred to specific features of construction and design, a hypothesis difficult to examine given the absence of archaeological evidence for warships. It is possible that each term referred to something as basic as the class size of vessels, each warship increasing in size in direct correlation with the increasing prefix. Alternatively, such designations were perhaps anachronistic in nature; over the centuries it became customary to refer to increasingly larger warships as a trireme, quadrere me, or quinquereme, without any reference to specific attributes associated with past vessels. Triremes were perhaps the smaller sized and most commonly constructed warships of the period, and were consequently mentioned more often in sources. Likewise, the larger warships, the quadrere me and quinquereme, were more rare and therefore mentioned less often by authors of the period. On the other hand, the terms may have referred to other design or construction features reminiscent of earlier warships such as bow/stern shapes, deckit or deck structures, sail placement, seat arrangements, or a suite of such features.

The term 'liburnian' is also a difficult reference to discern with the paucity of evidence available. Without sound evidence for construction details that differentiated a liburnian from the other warship types, we cannot be certain as to the specifics of each vessel, but it may also have been a term of size differentiation. Tenuous arguments have been postulated that these vessels were similar to a vessel type (the 'lembos') used in the third to second century BCE by pirates along the Dalmatian coasts (liburnia), that featured two banks of oars. Problematically, this association has a five-century disparity, and, as outlined in Chapter IV, the preponderance of iconographic and literary evidence indicates that there were only single-banked warships during this period. Thus, the term designating a two-bank warship is eliminated. Nevertheless, the historically derived geographical association of this term may in fact refer to other specific construction or design features that had become traditionally associated with certain warships, perhaps those in shipyards along the Illyrian coast. As with the other

terms, "liburnia" could have referred to a vessel’s length-to-beam coefficient and draft, plan shape, mast placement and rigging, stem or stern shape, number of rowing stations, performance characteristics, or the configuration of internal timbers. It is comparatively well understood that the term dromon referred to the vessel’s characteristic swiftness, and perhaps liburnia also had traditional performance characteristics resulting from its design that warranted the designation of this specific term.\textsuperscript{55}

**Command structure**

The command structure of the Imperial navy from the second to fourth centuries was organized in a similar manner to that of terrestrial military units. From an administrative perspective, fleets were regarded as part of the army through the mid-fourth century, with a magister militum in charge of both land and sea forces. Typically, a fleet of ships would have come under the direct command of a praefectus \textsuperscript{56}, while a centurion, together with his subordinate optio and armorum custos, would have commanded an individual ship.\textsuperscript{57} An example of an office commanding both land and sea forces was the dux litoris Saxonici, who was elevated to comes of the classis Britannica probably during the visit of the Emperor Constans (337-350) in 342-343. The holder of this military post was both a commander of the fleet and the associated forts on both sides of the channel.\textsuperscript{58}

Individual fleets remained under the command of praefecti well into the fifth century,\textsuperscript{59} but in the sixth century, Maurice refers to a change in the military command structure. Fleet supervision remained under the purview of a praefectus, but in subordinate positions below each praefectus were now the merarch (traditionally in command of a meros), moirarch (commanding a moira), and count or duce (commanding a tagma). For land units, a meros was composed of three moira, with each moira being comprised of several tagmata. The organization of large numbers of troops on land necessitated a thorough command structure. Such organization was also a requirement for organizing a large number of ships, particularly in maintaining tactical formations and coordinating large transport fleets during major campaigns. If the command structure for terrestrial units was literally paralleled in the fleet, a praefectus would command a fleet, merarchs would be assigned to a large grouping of warships and transport ships (a meros), and each meros may have been subdivided into divisions. These divisions were

\textsuperscript{55} It is understood here that construction features, performance characteristics, and aspects of design are interrelated.

\textsuperscript{56} Such as Marcius Agrippa, whom Aelius refers to as a praefectus commanding a fleet: Aelius Spartanus, “Severus,” 5.1-7.1.


\textsuperscript{59} Orosius, *The Seven Books of History against the Pagans*, 7.36.6.
possibly three moirae, each commanded by a moirarch. These moirae were delineated into smaller groupings of a few individual ships (a lagmo) that were commanded by a count or duce.60

Logistical roles of the fleets

The regular movement of troops, officials, and supplies to and from provincial garrisons was the primary logistical demand on the Empire’s military fleets. Couriers and officials also maintained communications between the far-flung provinces and the Emperor. As discussed in Chapter IV, the reduction of decorative elements on warships such as the goose head, deck projection, and inward projection represented in iconography from the period of circa 50 - 250 to those of circa 250 - 450 may indicate a change in the role of warships. During the former period, there were conflicts and military operations within the Mediterranean provinces that were best dealt with through the movement of troops and officials by sea. The highest-ranking officials were often transported by ship, whether it was an emperor on itinerant journey or generals moving to areas of conflict, as it was the most rapid form of transportation. It is likely that the large, elaborately outfitted warships conveying these officials would have been frequently seen in larger ports between circa 50 - 250, thus providing subject matter for artists. This transport of high officials on military duties would explain the number of standards and correlated decorative elements that were depicted on warship illustrations during this period (Chart 54). From around circa 250 – 450, military activity was concentrated along the Rhine-Danube and Britain fronts, which resulted in the hardening of border defenses with mobile cavalry units to intercept incursions.61 Military personnel, including officials, required greater overland and some riverine travel to reach areas of the European or Near Eastern hinterland. Ships primarily served a supporting role in the movement of troops and supplies (through the ammona system), but were less likely to be carrying emperors and other high military officials as regularly as in the previous period. Thus, with a larger amount of overland traffic, there was a decrease in observances of such officials in the Mediterranean, and in the elaborately outfitted warships that carried them. Warships frequenting ports in this latter period were more likely on patrol or escort duty.

The military’s task of supplying troops with food, equipment, wares, and other provisions, while maintaining an effective communications network grew increasingly complex as garrisons were stationed over larger areas. In preparation for war against the Persians in the winter of 361, Julian called for levees to be gathered from all over the Empire, including clothing, arms, siege engines, gold, silver, provisions, and pack-animals.62 The legionary office of procurator was responsible for obtaining and

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61 The troubles with the Parthians in the East continued, but were not of the same urgency or receiving the same attention as those along the Rhine-Danube front.
62 Ammianus Marcellinus, The Later Roman Empire, 21.6.5-6.
distributing all necessities of life, and coordinated much of the provisioning for the troops through the *annona* system.\(^{63}\) As the Empire’s borders hardened, an increasing number of personnel were required for guarding and policing duties. More troops necessitated an increase in provisioning, a wider resource base, both of which placed an ever greater demand on the distribution system.

Because military personnel were typically stationed far from the regions in which they were raised, troops were transported via ship in large and small numbers. Although the military focus had shifted from the Mediterranean to European provinces during the third century, troops continued to be transported over the Mediterranean during the Late Empire.\(^{64}\) Historical sources mention the more conspicuous events of extremely large-scale troop conveyance, although the transporting of troops was essentially a common activity for the fleet. Indeed, transportation by water was the only feasible mode of access for the governing of provinces such as Britain, Africa, and Egypt, and undoubtedly one of the most common of duties falling on the fleets operating in these areas. The movement of troops overland to and from North Africa and Egypt would have been too time consuming and expensive to be an effective option for more immediate military operations.\(^{65}\) Claudius’ (41-54) invasion of Britain in 43 marked the beginning of a considerable transportation commitment in an already widely extended network. Claudius and his successors were charged with the implementation and coordination of sea, riverine, and land transportation on an island bereft of any developed infrastructure. Naturally, transportation by water was of paramount importance, as it provided the sole means of communication and transportation between the island and the continent.

As one of the most heavily garrisoned provinces in the Empire, Britannia serves as a prime example of the formidable demand that transportation of troops, provisions, weapons, and other supplies placed on the fleet. A relatively large number of troops were based in many forts throughout Britain. These forts functioned as supply-bases for personnel who were often transferred to areas of conflict on the continent and returned once hostilities subsided.\(^{66}\) Furthermore, the garrisons of the province consisted almost exclusively of foreign soldiers, while native recruits were typically shipped to other provincial posts. Thus, replacement personnel and troops returning to homelands were frequently traveling to and from the island. Fortunately, this logistical testing ground that necessitated the rapid, reliable, and increasingly massive transportation of troops and supplies, is a well-documented and excavated

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\(^{63}\) Strabo, *Geography*, 3.4.20.

\(^{64}\) The evidence from Late Antiquity does not support Starr’s assertion that the fleet was rarely used for transporting troops: Starr, *Sea Power*, pp. 74-75.

\(^{65}\) This lesson was painfully learned by Nero (54-68), whose troops after being transferred via land were too exhausted to be of any immediate assistance once they arrived: Tacitus, *The Histories*, 1.31.

\(^{66}\) This outline includes the major troop movements to and from Britannia, though troop movements to and from the province were undoubtedly an extremely frequent occurrence.
provincial area. Initial demands on transportation by water consisted of the ferrying of Claudius’ invasion force of four legions and several auxiliary units across the channel. After a build-up of forces through the first century, and the expansion into Scotland by the 80s, Hadrian (117-138) ordered the construction and manning of a defensive wall between the Tyne and Solway. By the mid second century there was a garrison of nearly fifty thousand soldiers in Britain, and at the end of the century more units were sent to Britain from both Germany and the Danube.

At the end of the third century, the Saxon shore forts were constructed and garrisoned along the southeastern coast, with additional troops accompanying Constantius when he entered the province in 297. The archaeological and literary evidence suggests that the overall number of troops in Britain decreased only slightly through the mid fourth century. Again in the late fourth century, there was a

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67 Webster, *The Roman Imperial Army*, p. 105; G. Webster, *The Invasion of Britain*, p. 85.
68 Wales was sparsely garrisoned until second-century raids forced an increase in troop numbers and the construction of new forts. By the end of the third century, Wales had become almost completely abandoned. The legionary forces at York and Chester had the duty of preventing an invasion from the Caledonian tribes, with Chester having the additional duty of patrolling Wales: Welsby, *Defense of the British Province*, pp. 6-7.
69 Other principal troop movements included the *Legio VI Victrix* transported overseas from Germania Inferior to Britannia in 122 along with four cohorts, and the *I Aelia classica*. Troubles in Noricum and Raetia forced some vexillations to be withdrawn from the wall in the early second century and subsequently *alae* were sent to Germania Inferior. In the mid third century Britain’s heavy troop reserves were again tapped, when vexillations of *II Augusta* and *XX Valeria Victrix* were sent overseas to the Rhine. Despite troop reductions, a new fort was built at Piercebridge and manned in the mid third century. Later reinforcements consisting of both cavalry and infantry were sent to Britain after the defeat of the Gallic Empire in 274 and the defeat of Constantine Chlorus (305-306): T. Coello, *Unit Sizes in the Late Roman Army*, pp. 3-18; P. Holder, *The Roman Army in Britain*, pp. 17-19.
70 Many of the troops used to garrison these forts were drawn from the northern boundary forts: Welsby, *Defense of the British*, p. 57.
71 Evidence suggests a total of at least 25,000 Roman troops in Britain in the mid third century, with no solid archaeological or epigraphic evidence for troop reductions in the third and fourth centuries. Some scholars have argued that these forts were occupied by family units at this time due to the presence of artifacts possibly associated with women and children, suggesting fewer actual troops, although the evidence for this is far from conclusive: Ibid., pp. 87-89. Although often mentioned in discussions on the changing number of troops and associated fort remodeling in the third and fourth centuries AD, the idea that families were living in forts in ‘chalets’ (remodeled barracks) and that there was a consequent decrease in overall fighting forces at the forts has little evidential support: Coello, *Unit Sizes*, pp. 20-22, 54-55; R. Davies, *Service in the Roman Army*, p. 187.
72 This period was instead characterized by frequent, short unit reassignments to and from other overseas provinces. It is also plausible that during the later fourth and early fifth centuries, there was less a drastic reduction in total troop numbers than commonly put forth. For example Julian (361-363) dispatched troops to Richborough in 360 after confiscating boats for their transportation. Also four additional regiments were sent to Britain in 360 and 367. Later in the fourth century, Theodosius sent more reinforcements to the province after the ‘Great Barbarian Conspiracy’ of 367: Ammianus Marcellinus, *The Later Roman Empire*, 20.1.3, 27.8.7; Holder, *Roman Army in Britain*, pp. 18-19. Although some damage is evident in villas, there is no conclusive archaeological evidence of a large barbarian uprising.
strengthening of the coastal defenses, which included new fort constructions and renovations, accompanied by the associated increase in troop numbers. Rome's final abandonment of Britannia at the beginning of the fifth century entailed a massive redeployment of military personnel to the continent. The size of the Roman garrisons in Britannia varied from 25-30,000 troops in around 401 when Stilicho (the magister militum praesentalis in Italy from 395 to 408) began the final series of troop withdrawals for his war against the Visigothic king Alaric. In 407 the last of Legio II Augusta along with numerous cohortes were ordered back to the continent for the protection of Italy, ending Rome's military occupation of Britain.

There is ample evidence for the frequent overseas deployment of troops in areas throughout the Mediterranean during Late Antiquity as well. Septimius Severus (193-211) moved his forces via ships to Dyrrachium on the Adriatic coast in 193 prior to an engagement with Priscus Niger, and Constantius transported troops to Africa as protection against the enemy forces gathered in Sicily. In 367 the Praetorian prefect Auxorius used a fleet to move troops and provisions across the Black Sea and up the mouth of the Danube where they were transferred to river craft. In the late fourth century, troops were reportedly moved from Europe to North Africa and from Italy to the Greek peninsula, and four thousand troops were sent via ship to Ravenna from the East in support of Honorius (395-423). In the

and it may be that the event was magnified in order to secure increased protection from future threats: Welsby, Defense of the British, pp. 105-108. Valentinian (364-375) dispatched the general Jovinus and subsequently Theodosius to rectify the disorder wrought by the Germanic invasions in 367. Also, Theodosius gathered cavalry and infantry and crossed from Boulogne in Gaul to Britain, landing at Richborough. Here he garrisoned new fortresses while repairing existing fortresses and small forts in 369: Ammianus Marcellinus, The Later Roman Empire, 27.8.1-5; 28.3.3-6. These abandonments are partly associated with the drawing away of troops for the manning of the Saxon Shore forts and many were reoccupied by the mid fourth century. Despite the Roman setbacks, there is no evidence that any of the fifteen forts located on Hadrian's Wall were completely abandoned for any period of time, although some other northern forts were abandoned for a brief period in the mid to late third century.

Most notable among these abandonments and reoccupations were the forts of Piercebridge, Forden Gaer, Caernarvon, and Cardurnuk. Late fourth-century coastal defense sites include Burrow Walls and Lancaster on the northwestern coast, Caer Gybi on Welsh coast, Bittern on the south coast, and five signal stations on the Yorkshire coast. Welsby, Defense of the British, pp. 57, 92.

Magnus Maximus had already taken a large number of forces with him in 383 during his unsuccessful bid for the throne, but had prudently maintained an effective force in the province ensuring his power base. Coello, Unit Sizes, p. 19; Holder, Roman Army in Britain, p. 19.

Part or most of the VI Victrix appears to have been left at York, although a coherent defense of the northern wall system was brought to an end. Coello, Unit Sizes, p. 18; Holder, Roman Army in Britain, p. 129.

Holder, Roman Army in Britain, p. 19.

Ammianus Marcellinus, The Later Roman Empire, 21.7.2-4, 29.5.5-7; Zosimus, New History 4.10.4, 5.11.3-4, 5.7.1.

Olympiodorus, Works, 10.1; Zosimus, New History, 6.8.2.
fifth century Stilicho sent five thousand infantry overseas from Italy to Africa,\(^ {79}\) and in 470 Leo's (457-474) attempted invasion of North Africa involved a large number of troop transports.\(^ {80}\) The transportation of troops overseas continued into the seventh century when Heraclianus (610-641) commanded a fleet sailing from Africa to Italy.\(^ {81}\)

River crossings were also vital considerations when moving troops, especially considering that the Rhine and Danube rivers formed much of the Eastern European border. After transporting his invading forces by sea to Genoa, Belisarius was forced to rely on local ferries for river crossings while trekking across the peninsula towards Ravenna. Thus, as part of his later strategic planning, he opted to load the ships' boats onto wagons for the eventual crossing of rivers such as the Po, which freed his reliance on unpredictable local river transport.\(^ {82}\)

Throughout the Late Imperial period and Late Antiquity, the responsibility of transporting personnel and supplies fell on the fleets' transports. Provisions shipped to garrisons consisted primarily of grain, wine, olive oil, and fruits.\(^ {83}\) As the network of private merchants carrying such foodstuffs adjusted to garrison demands, some of the burden on the fleets would have been eased, but it was the ultimate responsibility of the army to ensure that adequate provisions were reaching the forts and depots. Evidence indicates that the agricultural circumstances in Britain, for example, responded slowly to the Roman presence, and exhibited little large-scale development until the fourth century. Roman military garrisons placed a heavy strain on the local farmsteads, whose primary output was geared for self-consumption, which normally left minimum surplus for trade. As a result, the bulk of foodstuffs for the military were imported following the conquest. Logistically, this provisioning task was best accomplished by direct military involvement in the shipping of foodstuffs, and by ensuring safe transportation routes to and from ports for private traders.

Cultural factors also played a role in the shipping of foodstuffs for military personnel such as soldiers, support staff, coloniae, officials, merchants, and craftsmen, who originated from Mediterranean

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\(^{80}\) Procopius, *History of the Wars*, 3.6.23.  
\(^{81}\) Orosius, *History against the Pagans*, 7.42.  
\(^{83}\) Many of the provision items that were partially or entirely imported are not represented well in the archaeological record. Foodstuffs such as grains, lentils, and fruit, typically only survive if charred or deposited in anaerobic environments. Furthermore, these items were often shipped in containers made of perishable materials. Unlike the present day excavations, poor methodologies of early excavations at many Roman fort sites destroyed the small amount of archaeobotanical evidence that may have existed. The majority of provision containerization available to archaeologists is in the form of amphorae, which principally represent the shipping of wine and oil. Hence, transportation evidence in the archaeological record is naturally skewed towards these two categories of foodstuffs. The scale of transportation for the
homelands. Deliberate posting of troops to garrisons far from their homelands, as was the case with Britain, exacerbated the demographics. Those from the Mediterranean who lived in provinces far from home continued to desire Mediterranean food such as olive oil, wine, and certain fruits. Letters found at fort sites indicate that families often sent foods items from home to their sons. While the more exotic foodstuffs were shipped to Roman forts, grains were a primary cargo that arrived in Britain from as far as the eastern Mediterranean.\(^{44}\)

Other goods, such as fine ware pottery, were also shipped to forts via military or private operations. Forts situated in hostile or undeveloped regions, such as the one planned at Inchtuthil, were frequently surrounded by populations who were unwilling and/or unable to provide acceptable pottery.\(^{45}\) Various forms of Samian ware (terra sigillata) were typically shipped from factories in southern and central Gaul. For example, Samian ware found at the Brough-on-Noe fort site originated in Southern Gaul, Central Gaul, and the Ritterling region in Germany.\(^{46}\) Similarly, the Samian ware excavated from Bar Hill, Colchester, and Silchester originated in southern and central Gaul.\(^{47}\) The Pudding-Pan Rock shipwreck site off the coast of Kent, dated to circa 175-200, also yielded terra sigillata from northeastern Gaul.\(^{48}\) Typically, Samian ware would not have been transported in large, individual shipments, except in the relatively infrequent circumstances of stocking a newly built fort in an area far from a trade center. More often, traders shipped these relatively expensive finewares as part of a larger cargo, with the main portion usually consisting of foodstuffs, armaments, or clothing. Hence the presence of Samian ware in military may thus be underestimated unless one takes into account the large quantities of these ‘invisible’ food items. Of these invisible items, grain was probably the most common bulk foodstuff shipped.

\(^{44}\) R. Davies, *Service in the Roman Army*, pp. 191-196.

\(^{45}\) M. Darling, “Pottery from early military sites in Britain,” in *Roman Pottery Studies in Britain and Beyond*, eds. J. Dore and K. Greene, p. 63.

\(^{46}\) M. Dearne, ed., *Navio: The fort and vicus at Brough-on-Noe, Derbyshire*, pp. 50, 80.


\(^{48}\) Roof tiles found nearby are also thought to belong to this cargo: A. Parker, *Ancient Shipwrecks of the Mediterranean*, pp. 343-344. Samian ware was not the only fine ware found in British fort sites indicative of importation and inter-provincial distribution. Glazed ware found at York came from Lyon and central Gaul, in addition to the Gallo-Belgic terra nigra in the assemblages: J. Perrin, “Legionary Ware in York,” in *Roman Pottery Studies in Britain and Beyond*, eds. J. Dore and K. Greene, p. 102. These fine wares were reaching as far north as the extended Scottish defensive lines of the early second century. Typically, the Antonine forts in Scotland had the fineware source pattern of Samian ware from southern and central Gaul, black-burnished ware from Colchester, fine ware from Dorset, black-burnished ware and mortaria from Rossington Bridge, Mancetter, and Hartshill, jars from the Severn Valley, and mortaria from various sites in northwest England: D. Breeze, “The Fort of Beadon and the Supply of Pottery to the Roman army,” in *Roman Pottery Studies in Britain and Beyond*, eds. J. Dore and K. Greene, p. 139.
forts throughout the Empire testifies to the far-reaching network of provision distribution, as evidenced, for example, by the ARS ware reaching Britain from the first through fourth centuries.99

The Roman campaigns in North Africa and Italy against the Vandals and Ostrogoths, respectively provide an excellent example of Roman logistical efforts in practice. Justinian moved against the Vandals initially by preparing an army reportedly consisting of 10,000 foot soldiers and 5,000 cavalry to be sent by a fleet of transport ships and warships to Carthage.90 Five hundred ships were required to transport these forces and their associated supplies. The largest ships carried approximately 50,000 modii, the smallest 3,000 modii, and the manning of the ships required 30,000 Egyptian, Ionian, and Cilician sailors.91 Assuming these numbers to be a realistic estimate of the size of the Roman army, some assumptions can be made concerning the carrying capacities of these vessels.92 If a conservatively estimated 10% of the fleet consisted of warships serving as escort, some 450 ships remained to transport 15,000 soldiers and 5,000 horses. Horses required specifically designed transports and their exact capacities in this period is uncertain. If on average each horse transport could carry a generous forty horses, one hundred and twenty-five such ships would have been required.93 The remaining three hundred and twenty-five ships transported the fifteen thousand troops, averaging just over forty-six men per ship. This seems a reasonable number, although the actual coefficient of large to small ships in the fleet is uncertain. Upon examination, Vandal troop transports appear to carry a similar number of men. King Geilamir (530-533) gathered five thousand Vandals on one hundred and twenty ships “of the fastest kind” for a military operation in Sicily. Each vessel, in this scenario, carried an average of just over forty troops per ship.94 Considering the large numbers of vessels involved in Justinian’s campaign, it is likely

90 Procopius, History of the Wars, 3.11.1-2, 3.15.36.
91 Ibid., 3.11.12-14.
92 Given that ancient writers had the tendency to overestimate numbers, that such large numbers as these given may thus be on the high side. If Procopius overstated proportionally, then examining the number of soldiers, horses, and supplies per ship is valid. Furthermore, it seems logical that even having inflated the numbers of troops, Procopius would have suggested a plausible number of ships needed to transport them, so as not to seem incongruous to the reader.
93 If horses were stood perpendicular to the keel line in two rows, one on each side of the ship, and 1.5 meters is allowed for the breadth of each horse, there would have been a required hold length of 30 meters. Allowing another 3-4 meters at the bow and stern places these vessels total estimated length between 36 and 38 meters, within the possibilities suggested by the archaeological evidence. The horses may have been picked up en route to North Africa as Belisarius docked the fleet at Heraclia (Eregli on the Sea of Marmara) to receive a large number of Thracian horses: Procopius, History of the Wars, 3.12.6-7.
94 Ibid., 3.11.23.
that vessels were of varying sizes.\textsuperscript{95} While larger ships maximized the efficiency of troop, equipment, and supply transportation, smaller vessels with shallower drafts were required to make the landing of troops and supplies ashore possible in areas lacking docking facilities.

After successfully arriving in North Africa, Belisarius landed his army at Caputvada, east of Carthage, where he organized his troops for battle. During the coastal march from Caputvada to Carthage the entire fleet shadowed the army's movements, and provided an emergency escape route should it be required, continuous access to supplies, and protection from a sea-born attack. This fleet also maintained communications between the invasion force and Byzantium, with messages between Belisarius and Justinian conducted by couriers aboard its ships.

Having secured North Africa, the fleet could now utilize Carthage's port facilities for moving troops into Sicily and Italy.\textsuperscript{96} With North Africa under Roman control, Belisarius was able to use the area's supplies to provision his army in the Italic campaign. Large quantities of mid-sixth century ARS found around the sites of Marseilles (Massilia), Cartagena (Cartago Nova), and the fort of S. Antonio di Pertì in northwest Italy, attest to the westerly travel of North African products. Excavations have also produced large quantities of Tunisian cooking wares and amphoras from Cartagena as well as a widespread distribution of North African amphoras containing fish sauce throughout the western Mediterranean.\textsuperscript{97} Supplies for Italian campaigns in the West were also arriving from the East, as evidenced by several early and mid-sixth-century Italian shipwrecks such as the Capo Passero,\textsuperscript{98} Marzamemi J.,\textsuperscript{99} and Siracusa B.\textsuperscript{100} The Roman military took particular care in provisioning armies engaged in siege warfare. Belisarius intended just such a use for his grain during prolonged sieges when stowing it aboard his fleet transports.\textsuperscript{101} Once the southern port cities of Italy were under Roman control, supplies were imported for storage and distribution to the army operating further north. Evidence of these shipments is found in the pottery assemblages from several sites, particularly those in Rome and Naples where the amount of Eastern amphora types increase in assemblages from circa 500 onwards.\textsuperscript{102}

\textsuperscript{95} The mix of large and small vessels in military fleets are assumed to be reflected in the archaeological record, where there is a grouping of seagoing vessels in the twenty to 22 meter and 30 - 32 meter ranges.
\textsuperscript{96} Indeed, Constantianus dispatched his entire army overseas to Italy. Ibid., 5.7.27-28.
\textsuperscript{97} P. Reynolds, Trade in the Western Mediterranean, A.D. 400-700: The ceramic evidence, pp. 119-120.
\textsuperscript{98} Parker, Ancient Shipwrecks, p. 121.
\textsuperscript{101} Procopius, History of the Wars, 5.14.17. Although, ideally, grain was eventually transported to granaries.
\textsuperscript{102} Reynolds, Trade in the Western Mediterranean, p. 134.
Sailing seasons were crucial in the organization of transport routes, as well as in the maintenance of supply and communication lines. Justinian faced this problem when he dispatched a newly raised fleet carrying reinforcements to Belisarius in Italy, but due to a seasonal miscalculation the fleet had to spend much of the winter in Greece. In another instance, the Roman fleet was forced to hastily leave the port of Ostia after it had delivered supplies and troops. It appears from such examples that in periods of war, transport ships were sailing the Mediterranean in November and possibly into early December. Considering that warships appear to have been dispatched year-round to address conflicts, as discussed above, they were probably engaged in year-round escort duties as well. However, the risk factors posed by winter seas assuredly factored into decisions to deploy naval forces. The rougher seas of January and February appear to have particularly discouraged the risk of crucial transport fleets when laden with troops, unless under the most extreme necessity.

In addition to troops, horses were often shipped as an accompaniment to cavalry regiments. Little is known about the specifics of horse transports in this period, except that they were frequently utilized. For example, in 175, five thousand Sarmatian cavalrymen with mounts were sent to Britain by Marcus Aurelius (161-180). There is evidence of a permanent ala milliaria stationed in Britain (the ala Augusta Gallorum Petrieina milliaria CR bis torquata) as early as the second century, which remained there into the fifth century. During the Empire’s campaign against the Ostrogoths, reinforcements arriving in Rome under the command of the generals Martinus and Valerian included some one thousand six hundred horsemen and mounts ready for battle. Subsequent reinforcements sent to Naples included approximately three thousand troops and eight hundred horsemen. The cost of specifically designed transports probably compelled these vessels to be redeployed whenever possible, although additional ships were undoubtedly built to accommodate inordinately large invasion forces. It is reasonable to assume that horse transports represented some of the largest vessels in the fleet.

Undoubtedly, there was both a similarity in, and dissemination of, technical knowledge over time between the builders of military horse transports and the private operations that built large ships for delivering animals for the games. To overcome the difficulties inherent in the loading and stowage of large animals, a problem that the shippers of larger circus animals also faced, horses were probably led aboard by a ramp situated at deck level, then down another ramp into the hold through a large deck.

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104 Holder, Roman Army in Britain, pp. 17-19.
105 Coello, Unit Sizes, p. 3.
106 Procopius, History of the Wars, 3.12.6-7, 5.27.1, 6.5.1
hatch.\textsuperscript{107} Although it seems unlikely that horses were kept in cages, each animal must have been secured well in place and their legs hobbled in some manner to deter them from rearing.\textsuperscript{108}

Riverine craft were also utilized as logistical support during the Italian campaign against the Ostrogoths, some of which appear to be innovative solutions to immediate problems. Typically, the Roman military employed river vessels to move personnel, as in the blockade of a Frankish-occupied island in the Meuse River earlier in the fourth century, where patrol vessels were utilized to cut off the enemy and deliver troops to the island.\textsuperscript{109} Initial Roman reinforcements arriving in Italy during the fifth century faced docking and off-loading difficulties because Portus, its barges, and warehouses were under Ostrogothic control. Eventually, the Romans gained control of the abandoned port of Ostia, although they remained without access to barges for transportation up river. As a solution, the crew boarded up the ships' boats on all sides to protect them from arrows, and sailed them, manned with archers, sailors, and supplies, up the Tiber. River bends caused difficulty as the wind was coming "from the side", forcing them to row for stretches.\textsuperscript{110}

Equally ingenious was the defense strategies devised to protect troops against enemy vessels in riverine operations. Outnumbered Imperial forces erected a fortified tower next to the Mulvian Bridge north of Rome to protect the newly acquired city from the approaching Ostrogothic army who could potentially utilize the numerous river vessels accessible along the Tiber. The Romans relied on the tower to provide superior positioning from which they could fire down on the Ostrogoths who would be forced to loose time either rounding up small ferries and boats for the crossing or constructing a boat bridge. The tower successfully impeded Ostrogothic progress over the river, rendering access to local river vessels fruitless, and allowed Roman reinforcements time to arrive and prevent Rome's capture.\textsuperscript{111}

The rapid movement of troops and equipment over rivers was crucial due to the inherent tactical vulnerability of a force during a crossing, and in the need to keep on schedule. Less labor-intensive or technological methods of traversing rivers were employed by small numbers of troops on the march. Cavalry soldiers, for example, pushed a reed raft carrying their weapons and pulled their horses behind

\textsuperscript{107} This would be a solution equivalent to the methods that were apparently used for loading elephants discussed in Chapter 5.

\textsuperscript{108} This could have been easily accomplished in several ways: straps running from hind legs to opposite fore legs, a short strap between their fore legs, or a strap running from their halter to a hind leg.

\textsuperscript{109} Ammianus Marcellinus, The Later Roman Empire, 17.2.23.

\textsuperscript{110} This sailing difficulty illustrates the limitations of using square-rigged vessels. The mission was successful, for Belisarius received his supplies and reinforcements in Rome. Such a maneuver was completely contrary to the method for normally moving boats up the Tiber. Undoubtedly, provision was made in the boarding up the sides to allow the passage of oars for such a circumstance. Procopius, History of the Wars, 6.7.5-12.

\textsuperscript{111} Ibid., 5.17.14-7.
while swimming.112 However, in larger campaigns, bridges were necessary for moving great numbers of troops and equipment rapidly over a river, particularly where sizable rivers and dangerous currents were concerned. River boats were often used in the formation of pontoon bridges to cross rivers where permanent bridges were unavailable. Julian, in his campaigns against the Alamanni on the Rhine, built a bridge of boats in 357, and again in 359 to continue his campaign. He again utilized a bridge of boats to cross the Euphrates and Khalavi Rivers in a reprisal attack during the Persian campaigns in 363. This tactic was common to both sides, as the Persians used boat bridges to cross rivers during their invasion in 361.113 Maurice detailed the construction of a boat bridge across a river and emphasized the need for skiffs to complete the construction. He further urged that pontoons and beams be carried on campaign for use as construction materials. A clear depiction of such a boat bridge is found on Trajan's column, where the planks forming the bridge road are clearly lying atop a series of boats. These underlying craft were securely anchored in order to ensure the stability of the bridge. This was often accomplished by securing the boats to large bags of stones thrown overboard.

The fleets and communications

Inter-ship communication during voyages was an essential component of successful military operations and was primarily conveyed via signaling. There are representations of warships in which banners and standards were depicted. Standards designated a commander's ship, often the lead ship, on which the fleet keyed during a voyage. Banners likely served similar functions and were present in a number of illustrations of the period. Auditory signals also played an important role, with a bucinator (or bugler) commonly found among the crew of an early-Imperial warship. Apparently auditory signals, and perhaps the bucinator, survived into the sixth century as Maurice notes that heralds were used along with trumpeters for signaling between ships.114 Acoustic signals would have been indispensable at night or in low visibility conditions when banners were not easily visible. Auditory signals relayed a signal simultaneously to each vessel, had a greater success of being observed than did visual signals, and thus enabled better coordination of fleets.

Justinian's forces relied extensively upon these methods of signaling during the campaign against the Vandals in 535. The Praefectus Calonymus, who was in charge of the Imperial invasion fleet, had three ships designated as command carriers that provided communications for the fleet during the three-month voyage to Carthage. While sailing by day the fleet visually keyed on the ships of the three commanders that were painted red on the upper corner of their sails for one third of their total

112 Webster, Roman Imperial Army, pp. 234-235.
113 Ammianus Marcellinus, The Later Roman Empire, 16.11.6-10; 17.1.1-3; 18.2.14-15; 18.7.1-2; 21.7.3-4; 23.2.5-6; 23.5.4.
114 Maurice, Strategon, 12.B.21.
length. At night the lead ships hung lights from a pole attached to their prows, and to prevent collisions, crews from each ship shouted to advertise their positions and utilized poles to shove their vessels apart. Trumpets signaled the departure from the harbors at which they stopped en route.\textsuperscript{115}

Ships not only had communication duties while on duty, but were also used for the transporting of written and personal communications. The Roman government operated a postal system that linked the cities of the various provinces, and later the dioceses, in order to deliver messages to military and administrative officials. Septimius Severus revamped this \textit{cursus publicus}, increasing its administration and duties to include the transportation of provisions to the army. While the Master of Offices and the Praetorian Prefect shared some of the administrative duties, passes for food and lodging (or \textit{diploma}) appear to have been dispensed only by the Emperor, who ultimately oversaw the regulation of the post.\textsuperscript{116}

Messages were often carried by envoys or by a traveling official. Constantius, for example, sent his notary by ship from the Levantine coast to Africa,\textsuperscript{117} and during Aegidius' campaign in Gaul, envoys were sent to the Vandal king Gaiseric (428-477) via the Atlantic sea route since southern Gaul was hostile territory.\textsuperscript{118} Additionally, Zeno (474-491) sent an embassy to the Vandals in the 480s, and Justinian sent an envoy overseas from Byzantium to the Vandal king Geilamir in 527.\textsuperscript{119} There were also instances of emperors themselves making overseas journeys, and undoubtedly discharging commands that would otherwise be communicated by envoy. Septimius Severus (193-211) returned to Rome in 203, after four years of traveling through Egypt and other Eastern lands, only to set out again for Africa that year, and in 208 campaigned in Britain. He relied upon sea, and river transport to a lesser extent, for the longest legs of his journey. Caracalla (211-217) also utilized ships in his voyage from the Aegean to Asia, Gordian III (238-244) traveled to the East by ship, and Constans (337-350) visited Britain in 342/343 with his military entourage.\textsuperscript{120} River vessels were vital in maintaining communication, albeit they were utilized on a smaller scale. In addition to carrying messages, these vessels sometimes served as the meeting site itself. Julian arranged a meeting with the leader of the Chamvi aboard boats in midstream.\textsuperscript{121} As noted in Chapter IV, the iconographic evidence portrays fewer standards on Mediterranean warships after around 250, suggesting overseas travel by emperors and high officials had decreased after the mid-third century.

\textsuperscript{116} Cassiodorus, \textit{Variae}, 44. Not only was the kingdom interconnected by the post system, but correspondences with overseas governments were also handled through the system.
\textsuperscript{117} Ammianus Marcellinus, \textit{The Later Roman Empire}, 21.7.1-2.
\textsuperscript{118} Aegidius was campaigning against the Visigoths in the south of Gaul during the 460s because the \textit{magister militum} in Gaul had broken away from Roman control.
\textsuperscript{120} Dio Cassius, \textit{The Roman History, Volumes 1-9}, 77.16.7.
\textsuperscript{121} Eunapius, \textit{Works}, 3.18.6.
Threats at Sea

Many arguments for a decrease in Roman naval operations during the Late Empire, and specifically for the role of warships, have been inferentially deduced, based on both a diminished piratical threat to merchant ships and the lack of a true enemy power at sea to necessitate their continuation. Strabo refers to a lack of fear from piracy, and is often cited as sufficient proof of safe waterways under Roman rule. However, Strabo was writing in the late first century BCE, within a few decades of Pompeius Magnus’ decimation of the major Mediterranean pirate fleets in 67 BCE. His statement, therefore, is a reflection of events in the first century BCE, and cannot provide testimony to maritime state of affairs during the later Empire for all the Mediterranean and North Sea. Epictetus, writing nearly a century and a half after Pompeius Magnus’ campaign, also mentions the safety of sea travel, but he could just as likely have been referring to an effective protection against piracy provided by fleet operations at the end of the first century, as opposed to an absence of piracy pertaining to the Mediterranean as a whole. If he were referring to an absence of piracy, this begs the question as to why he specifically mentions piracy if it had not been a problem for centuries. Once more, due to the time frame, his statements cannot be used to clarify the situation concerning piracy during the Late Empire and Late Antiquity. It seems plausible that the problem of plaguing pirate fleets up to 69 BCE were effectively countered through the implementation and maintenance of a strong naval presence, a lesson that was undoubtedly understood by later rulers as well. The high volume of shipping during the second and third centuries provided plentiful targets and potential high rewards for pirates. It is a difficult argument to formulate that piracy would have been eliminated once and for all during the mid-first century BCE. Moreover, the continued presence of a strong naval force would not guarantee the end of piracy, no more so than having legions, forts, guard-posts, and patrols along important Roman roads ever put an end to brigandage.

Piracy was again troublesome for the Empire by the third century, and “...no country (was) sheltered from the fury of pirates, whenever it (was) within the reach of a ship.” Increased piratical activities and raiding had notable repercussions for the Romans, particularly in the North Sea, where they struggled to provide adequate protection for their transport fleets and coastal towns. Dangers at sea were prevalent throughout the North Sea into the mid-fourth century, as was indicated by Julius

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122 Strabo, Geography, 3.2.5; Epictetus, Discourses, 3.13.9; Starr, Sea Power, pp. 73-75.
123 Epictetus, Discourses, 3.13.9.
124 Nazarius, Panegyricon to Constantius Chlorus, 18.3.
125 Haywood is correct in cautiously interpreting coin hoarding and settlement abandonment data as indicating a general increase in raiding but not specific raids themselves: J. Haywood, Dark Age Naval Power, A Reassessment of Frankish and Anglo-Saxon Activity, pp. 32-33. Furthermore, raids by land must also be considered, even for those in coast or riverine areas.
Maternus’ observation that the channel crossing was “hazardous due to the presence of barbarians.”

Although these statements referred particularly to threats in the North Sea, references to Mediterranean piracy are found in third-century Roman law. The Germanic and Scythian invasions of the third to fifth centuries provided an ideal environment for piracy to thrive, as the Romans lost control of territories and had their military resources vastly overextended. These marauders attacked merchant vessels and port cities. In 376 when the Scythians penetrated the Bosphorus and the Sea of Marmara with two thousand ships, they harassed the coastal areas for a short time and won an initial sea battle with Imperial forces. The Heruli also took to the sea and attacked the territory of Lucus, the coastal areas of Cantabriae, and Vardulliae sometime in 456.

The increased pressure to protect provincial lands required the maintenance of several fleets, and there are numerous references to fleet participation in military operations during Late Antiquity. The North Sea, in particular, required a continuous Roman naval presence during the height of the Empire. By the end of the first century, Roman forces were well established in Britain and the fleet had circumnavigated the island. As early as the third century, Franks and Saxons were conducting raids with sufficient force and frequency to threaten Roman assets, as well as the routes by which they were conveyed. In response to persistent incursions, a system of forts were constructed along the shores of Britain, Gaul, and lower Germany during the second to fourth centuries. These fortifications were coordinated with fleet patrols and often served as their bases of operation. By the early fourth century, Roman naval forces were again in control of the seas and the British-Gaul trade routes. During the 360s, Julian sent a large fleet to Britain to assist general Charietto in the submission of rebellious Frankish and Saxon tribes who struck Britain during the 360s. However, Britain was not alone in suffering these incursions, as “…the Franks and Saxons were losing no opportunity of raiding the ports of Gaul nearest to them by land and sea, plundering, burning, and putting to death all their prisoners.”

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126 Julius Fimicus Maternus, De Eiore Profanarum Religionum, 38.6.
127 Ulpian, The Civil Law, 4.9.3.1, 47.9.3, 14.2.23; Starr, Sea Power, p. 74.
128 Ammianus Marcellinus, The Later Roman Empire, 31.5.12-17.
129 Hydatius, Chronicles, 164.
130 The need to supply the forces with foodstuffs, weapons, and reinforcements during their governance, discussed in the previous chapter, was handled to some degree by the classis Britannica.
131 Tacitus, Agricola, 38.
132 Forts and ports in southeastern Britain and northern Gaul were upgraded in the mid and late third century. Although some were undoubtedly built by Postumus in his efforts to secure his territory from Imperial retribution, they were later available to the Empire for defense against Germanic raiding. Haywood, Dark Age Naval Power, p. 35.
133 A combination of raids has served as a basis for the scholarly debate of the ‘Barbarian Conspiracy of 367’. While it is difficult to ascertain the degree of coordinated ‘conspiracy’, the Franks and Saxons were prominent among the raiders.
134 Ammianus Marcellinus, The Later Roman Empire, 26.4.
Patrolling the entire coastline of southeastern Britain and northern Gaul required enormous resources. Some areas were inevitably left vulnerable and small mobile units of Germanic war parties eluded the Roman defenses. The warships of the *classis Britannica* served not only to protect the high traffic of transports and mercantile activity, but also maintained a vigilant watch on the stretches of coastline between the forts in order to alert shore forces to enemy presence. Haywood suggests this may have represented a Roman strategy of using both ship patrols and strikes on Roman settlements as an alarm to the forts, from which forces were sent to attack the departing intruders.\(^{135}\) This strategy may have been an unfortunate circumstance resulting from an impossibly overextended defensive network and the limited ability of warships to intercept raiding vessels. Obviously for the sacrificed communities it was less than an ideal situation.\(^{136}\)

Accounts also indicate that numerous fleets plied the Mediterranean on military operations over the period under study. Septimius Severus (192-211) used a fleet to besiege Byzantium during its support of Priscus Niger in 193, and Theodosius (379-395) utilized his Eastern fleet in his journey to the Adriatic, and subsequently on to Sicily in 388. A fleet was also operating in the Hellespont in 400, and the *magister militum praesentalis* in the East, Aspar, dispatched a fleet on campaign to Italy in circa 425.\(^{137}\)

Relinquishing the province of Britain freed transports and warships for efforts in the Mediterranean in the fifth century. This was undoubtedly a critical factor for the increased naval activity by Germanic and Scythian groups that soon followed. It was primarily, however, the rise of Vandalic maritime power in North Africa that presented a challenge to the Roman domination of the Mediterranean. In 458/459, Majorian (457-461) prepared a fleet for a preemptive strike on the Vandals and he reportedly collected three hundred ships for this venture. Before the attack could commence, however, the Vandals struck and destroyed the Roman fleet while it was moored near shore.\(^{138}\) Although this effectively put an end to immediate operations against the Vandals, and was a setback for the Empire as a whole, it illustrates the Empire’s economic and military ability to marshal significant naval resources for overseas campaigns in the fifth century.

By the time Justinian entered into war against the Vandals in 533, it seems that the Roman

\(^{135}\) Haywood, *Dark Age Naval Power*, p. 37.

\(^{136}\) A most fortunate occurrence for a squad of patrol vessels must have been catching a raiding party at sea before they could land.


\(^{138}\) Isidore, *History of the Kings*, 76; Priscus, *Works*, 36.2. If this figure is not exaggerated, the majority of this number must have been sailed transport vessels, although warships would have comprised some of the fleet.
military had taken a hiatus from offensive stratagems to rebuild its forces after various setbacks, primarily due to incursions from the North and East." This respite appears to have included a temporary decrease in naval operations, as troops were dismayed with the prospects of a war effort against the Vandals due to the significant amount of fighting at sea which they presumed would be involved, and for which they were not well trained or practiced. Furthermore, they were undoubtedly wary of the reputation of Vandals for successful fighting at sea. Although the last noted victory over the Vandals at sea was eight decades earlier, the Vandals were undoubtedly flexing their naval might throughout the end of the fifth and beginning of the sixth century.

Respect for Vandalic sea power was also reflected in Roman strategy. Belisarius, for example, chose to disembark with his troops on the North African shore some distance from Carthage in order to confront the Vandals on land. Moreover, a direct attack on Carthage itself would have been a difficult task for even the most experienced seamen due to the thick defensive walls surrounding the approach to the harbor and large chains stretched across its entrance from the Bay of Kram that formed an effective obstacle to sea attack. Eventually the Vandals were decisively beaten in a land engagement with the Roman army, and the Vandalic Kingdom was eliminated from the Mediterranean.

After their victory in North Africa, the army of the Eastern Empire under Belisarius proceeded to attack the Ostrogothic kingdom in Italy. First, however, he led an attack on Sicily and Corsica in order to annihilate the remaining Vandal units that had been absent from Carthage during his North African campaign, but shortly had confrontations with Ostrogothic forces as well. The Ostrogoths were attempting to capitalize on the Vandal defeat and lay claim to these islands for themselves. Despite an initial victory by the Ostrogothic forces over the Romans in 535, Sicily and Corsica soon fell to Roman forces, who subsequently secured the Dalmatian coast in 536 to prevent rear actions during the

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139 He declared to campaign on behest of the Roman citizens that were suffering under Vandal rule. Procopius, History of the Wars, 3.20.20.
140 Ibid., 3.10.5-6.
141 Having caught the main Vandal forces out of well-protected Carthage on a raiding expedition, the land campaign was a complete success and Belisarius defeated the Vandals after only three months of fighting. Isidore of Seville, History of the Kings, 83; Procopius, History of the Wars, 4.3.28.
142 The inland portion of Carthage's wall was faced with stone, with rubble in its core, and had towers placed at intervals: C. Wells, "The Defense of Carthage," in New Light on Ancient Carthage, ed. J. Pedley, pp. 47-65.
143 J. Humphrey, "Carthage and the Vandals," in The Late Roman West and the Vandals, ed. F. Clover, p. 8.
144 Subsequently, North Africa's resources were utilized for further war efforts in Italy and Spain, as well as supplying foodstuffs for Byzantium, all of which was carried out by the use of ships. Italy was especially coveted by Justinian as it was the homeland of the Roman Empire.
move against Italy. In conquering Sicily, the Roman generals Mundus and Belisarius quickly secured all port cities except Palermo (Panormus), which was robustly fortified with high walls. Belisarius utilized his naval forces and besieged this city from the sea. After ordering his land forces to fall back, he sent his fleet into the harbor with orders to anchor the ships adjacent to the city walls, with their masts close to and extended slightly above the topmost courses of the ramparts. Belisarius then "filled all the small boats of the ships with bowmen and hoisted them to the tops of the masts," from where they could fire over the walls, and subsequently delivered the city into the hands of the Romans. Whenever possible, Roman forces utilized these tactics in the coastal portion of the Italian campaign. For example, Belisarius' fleet paralleled his march up the western coast of Italy from Bruttium, thus providing an emergency escape option if one was required. However, unlike the advantage of surprise enjoyed when striking the relatively unprepared Vandalic forces, the port cities of the Ostrogoths bristled with enemy troops ready for battle. The defenses of Naples were most perilous, and the Romans were forced to anchor their fleet in the harbor a good distance from the city in order to remain outside the range of Ostrogothic missile fire. Once their forces were in place, however, the tactic exploited successfully in Sicily was again employed, and Naples was simultaneously besieged from both land and sea. Despite these tactical successes, the war in Italy dragged on for decades and required a well-established shipping network for conveying supplies and reinforcements. Troops were alternatively deployed by land and sea to keep the Ostrogoths off balance. In 522, for example, a Roman army marched through the Balkans into Italy, while another force landed in Calabria and took Croton. The ability to maintain reliable logistical support by sea was a major factor in Roman success.

The Vandals

The Vandals invaded North Africa in the early fifth century and by 435 had occupied Carthage. In their struggle to become a recognized state within the Mediterranean community, the Vandals moved rapidly to make use of ships and associated naval assets they had acquired in the conquests. With their conquest of Carthage, they acquired not only the vessels moored there, but also the associated shipwrights, shipyards, and docks that manufactured them. Also fortunate for the Vandals, these facilities were sizable and well equipped for large-scale ship production. Carpenters and craftsmen had

145 In 535 Roman forces were repulsed by these recently arrived Ostrogothic forces at Lilybaeum, Sicily, thus beginning the direct conflict between the Roman Empire and the Ostrogothic Kingdom. Procopius, History of the Wars, 4.5.1-18.
146 Ibid., 5.5.11-17.
147 Ibid., 5.8.4-6, 9.8
148 It is little wonder that the Vandals had to be eliminated before a serious campaign in Italy could be pursued.
149 Perhaps the Vandal attack on Carthage while under treaty was an attempt to catch the Romans off guard, and prevent the mass evacuation of assets, including those associated with maritime operations.
thrived in Carthage for centuries, building and repairing the numerous vessels that frequented one of the largest ports in the *annona* system. These same shipwrights, carpenters, craftsmen, and other laborers undoubtedly found employment with their new Vandalic overlords. The production of ships for fleets required not only skilled labor, but also adequate financing. Military actions constituted a significant source of revenue for the Vandal state and, along with trading activities, provided the Vandalic government with substantial revenues for many years.\(^{150}\) Much of the income from raiding activity was in the form of precious metals, artworks, and other valuable treasures from foreign cities, while trading ventures brought in both currency and foreign goods. This acquired wealth facilitated the production of coinage, and thus helped to provide a capital base for the economy. Such a capital base was crucial for the building and maintenance of a strong fleet. Carthage's mints drastically increased their scale of production under the Vandals\(^{151}\) and were actively producing silver coins during the reigns of Kings Gunthamund (484-496), Thrasamund (496-523), Hilderic (523-530), and Geilamir (530-533).\(^{152}\) Large bronze coins with images of Carthage were also issued under the Vandal kings.\(^{153}\)

With a fleet as his disposal, King Gaiseric carried out extensive sea raids from his bases on the islands of the western Mediterranean to the coasts of the lower Balkans.\(^{154}\) Sicily and Sardinia lay within three days sail of Carthage and suffered frequent Vandal incursions.\(^{155}\) Gaiseric invaded Sicily and Italy at the beginning of every spring, ravaging the coasts and attacking cities.\(^{156}\) He eventually extended his seasonal incursion range to include Illyricum, Greece, and other Aegean islands.\(^{157}\) The threat of Vandal attacks on the Eastern capital were addressed by extending the walls of Constantinople during the

\(^{150}\) The Vandals engaged in both trade with, and attacks on, cities. The widened trading pattern in the Mediterranean is reflected in the evidence indicating a shift in African trade goods from Italy to Spain and southern France. In addition to the direct benefit of looting settlements, these attacks may have acted as an enforcement mechanism to ensure open markets. Long term and more consistent wealth from trade benefited a larger portion of the population than raiding. Although these operations were characterized as raiding and piracy from a Roman perspective, they were nevertheless justifiable military actions.

\(^{151}\) F. Clover, *The Late Roman West and the Vandals*, p. 13.

\(^{152}\) Humphrey, "Carthage and the Vandals," in *The Late Roman West and the Vandals*, ed. F. Clover, pp. 8-16.

\(^{153}\) These were probably issued by the Curia. W. Wroth, *Catalogue of the Coins of the Vandals, Ostrogoths, and Lombards and of the Empires of Thessalonica, Nicaea, and Trebizond in the British Museum*, pp. 100-101. Due to the rich food producing lands of North Africa, these revenues were not required for basic foodstuffs and allowed the Vandals to invest in other areas such as naval assets.


\(^{154}\) The indigenous North African Mauri cooperated with the Vandals immediately following the conquest, participating in these overseas raids. Humphrey, "Carthage and the Vandals," in *The Late Roman West and the Vandals*, ed. F. Clover, p. 2; Procopius, *History of the Wars*, 3.5.22-3.

\(^{155}\) Procopius, *History of the Wars*, 3.25.20-1.

\(^{156}\) Isidore, *History of the Kings*, 75.

\(^{157}\) In Greece the Vandals attacked the cities of Taenarum and Zacynthus in the Peloponnesus Procopius, *History of the Wars*, 3.5.22-3, 22.16-8; Priscus, *Works*, 38.1, 2, 39.1.
430s.\textsuperscript{158} By 439 the Vandals had wrested sea power from the Western Empire and were now in control of the Balearic Islands, Corsica, and Sardinia. They also vied with the Empire, and later with the Ostrogoths, for control of Sicily, Italy's primary remaining source of grain; by 440 they had seized control of Bruttium and Sicily.\textsuperscript{159} In 445 they attacked the shores of Gallaecia and followed with an assault on Turonium where they took hostages aboard their ships.\textsuperscript{160} The Vandalic fleet was also active along the shores of northwestern Hispania by the mid-fifth century.\textsuperscript{161} Such aggressive use of naval forces led to rising tensions with the Empire, culminating in an attack on Rome in 455. Gaiseric raised a great fleet and sailed unopposed to Rome,\textsuperscript{162} where he sacked and plundered the city, reportedly filling his vessels with as much booty as they could hold and returned to Carthage with the loss of only a single ship en route.\textsuperscript{163} However, the Vandals were not completely invincible at sea. In 456/457, they attempted an attack on Italy and Gaul with a fleet of sixty ships, but were beaten back in a sea battle near Corsica.\textsuperscript{164} Shortly thereafter, the Vandals successfully attacked a Roman fleet near Spain, temporarily averting Roman threats. After this attack, Majorian was forced to retreat from Spain to Rome over land via Gaul, which indicated that the Vandals had certainly captured the Roman fleet and were in control of the western Mediterranean at this time.

Vandal naval tactics had rapidly developed from the simple utilization of what were probably merchantmen to deliver land forces in the early fifth century while in Spain, to a level where they were able to compete with the powerful Roman naval fleets several decades later. In 468, the Empire retaliated against the Vandals first by conquering Tripolis, then followed by a march on Carthage after abandoning their ships. Forewarned of the approaching Roman fleet, the Vandals took the tactical initiatives. Gaiseric filled a portion of his ships with fighting men and left other fast ships empty. The empty ships were towed behind sailing vessels, but once in proximity of the Roman fleet their sails were raised, the hulls set ablaze, and they were hurled towards the enemy. The Roman fleet's formation became disorganized while attempting to evade or push away the blazing vessels with poles. This allowed the Vandals to easily surround, ram, and/or board the Roman ships.\textsuperscript{165} These proactive tactics demonstrate Vandalic ingenuity and proficiency in the use of naval assets. With such successes behind

\textsuperscript{158} Priscus, \textit{Works}, 10.
\textsuperscript{159} Cassiodorus, \textit{Variae}, 1.4.14.
\textsuperscript{160} Hystadius, \textit{Chronicles}, 123.
\textsuperscript{161} Ibid., 131.
\textsuperscript{162} Priscus, \textit{Works}, 30.1. 3.
\textsuperscript{163} Isidore, \textit{History of the Kings}, 77; Procopius, \textit{History of the Wars}, 3.5.1-5.
\textsuperscript{164} Hystadius, \textit{Chronicles}, 169.
\textsuperscript{165} Procopius, \textit{History of the Wars}, 3.6.1-22.
them, the Vandals grew bolder in their military sea ventures. Soon afterwards during the reign of Zeno (474-491), the Vandals attacked and seized Nicopolis, which brought the threat closer to the seat of the eastern capital.\textsuperscript{166} By 533, however, the Vandalic maritime dominance was to draw to a close, when Justinian broke their power in North Africa through a massive campaign. The final gasp of Vandalic naval power occurred in 533 when King Geilamir’s brother, Tzazon, landed at the harbor of Caranalis in Sardinia and captured the port city in an attempted effort to regain control of the island.\textsuperscript{167}

Vandalic warships were undoubtedly very similar, if not virtually identical, to contemporaneous warships of other Mediterranean powers; they were being single-banked, fast, maneuverable, with a full deck, and carried one or two masts. These warships presumably required relatively calm seas for effective rowing at any time during the year, just as did the Roman warships. Loaded with the royal treasure, when Geilamir was fleeing from the port of Hippo Regius to Spain after the Vandal defeat, his sailed warship was blown back to Africa by a strong wind. The crew was then ordered to row for a nearby island, but the seas proved too rough.\textsuperscript{168} Hence, sixth-century Vandalic warships were capable of both oared propulsion and sailing, as were their Roman counterparts. Such a passage may indicate that the oarsmen sat low in the hold, which created a somewhat low angle of entry for their oars, since turbulent seas would have interfered with the ability of low-angled oars’ to grab water as effectively as those of higher angles. The similarity of Vandal warships to those of the Romans is not unexpected, since the Vandals inherited numerous vessels of the *classis Africanus* when they seized Carthage, and additional ships after capturing Majorian’s fleet anchored off the Spanish coast in 460. Roman warships must have provided the foundation for the Vandalic fleet and served as models for their ships.\textsuperscript{169} Furthermore, shipwrights in Carthage were undoubtedly already trained in Roman warship construction.

Ships were also crucial in the interaction with other states. Envoys traveling aboard ships served as a means of communication between the Vandal kings and the Empire and Scythian states of the Mediterranean. Although the majority of these envoys were probably under the auspices of the military, merchant voyages to a distant port were assuredly prevailed upon to carry messages as well. Many such messages were conveyed regularly to the larger Mediterranean ports from Carthage. King Geilamir, for example, often utilized merchant ships to carry messengers.\textsuperscript{170} However, urgency and reliability of

\textsuperscript{166} Malchus, *Works*, 5.
\textsuperscript{168} Ibid., 4.4.35-7.
\textsuperscript{169} Hydatius, *Chronicles*, 195, 205.
\textsuperscript{170} Cassiodorus, *Variae*, 3.25.10.
crucial messages may not have been as easily trusted to this option as often as to those under military direction.

The Ostrogoths

In a manner similar to that of the Vandals the Ostrogoths, who had established themselves in Italy by the end of the fifth century, also utilized sea technology not only for trading ventures but also for government and military operations. Having settled in a territory rich in naval traditions and possessing numerous port cities with active shipyards, the Ostrogoths were able to quickly integrate transportation by water technology into their own sphere of expertise. Their later arrival placed them at an immediate disadvantage to the more established Roman and Vandalic fleets that were vying for control of the Mediterranean. There is little evidence that the Ostrogoths developed a fleet of warships that would have allowed them to compete in open sea on a large scale with the Vandals or Romans. However, they eventually marshaled a naval force capable of assisting in the defense of Italy. Although this fleet alone was not formidable enough to thwart all attacks. According to Cassiodorus, King Theodoric (493-526) ordered the building of 1,000 dromons to address his concerns about the ability of his state to compete and survive in an increasingly dangerous maritime environment.\textsuperscript{171} Despite the request, there is no evidence that this fleet was ever completed in its entirety. Indeed, Procopius relates Theodoric's growing disillusionment with his inability to marshal adequate sea power to drive the Vandals from North Africa.\textsuperscript{172} However, the Ostrogoths were able to defeat a Vandal raid on Sicily in 491, and Theodoric successfully attacked the port of Ariminum (Rimini) during his blockade of Ravenna in 492.\textsuperscript{173} In 508 Anastasius (491-518) ordered naval raids on the Italian coasts, possibly in support of the Frankish king Clovis (481-511). Successful Vandalic and Roman attacks on the Italian coastline indicate an Ostrogothic fleet of modest proportions. Ostrogothic maritime interests did not falter with the Roman invasion, however, and remained concerned with the sea defense of Italy's coasts. King Totila (541-552) raised a fleet that was utilized for attacks on Dalmatia in 549, Sicily in 550, and Corfu and Epirus in 551. Unfortunately for the Ostrogoths, this fleet was destroyed in 551 during an engagement with a Roman fleet at Ancona.\textsuperscript{174} In addition to their regard for warships, the Ostrogoths were similarly aware of the need for troop transports, particularly during their war with the Empire. The Ostrogothic general Vittigis, for example, sent troops in transports to recover Dalmatia. The transports were accompanied by warships to provide protection from the Roman fleet.\textsuperscript{175}

\textsuperscript{171} Ibid., 3.14.4.
\textsuperscript{172} Procopius, \textit{History of the Wars}, 3.9.3-5.
\textsuperscript{173} Ennodius, \textit{Works}, Panegyrics 23.
\textsuperscript{174} Procopius, \textit{History of the Wars}, 9.16.9-11
\textsuperscript{175} Ibid., 25.7.35, 37-39; 8.22-23.
Unfortunately, there are no extant detailed descriptions of Ostrogothic naval engagements or tactics, although sources do hint at details. Combined sea and land attacks on port cities were a tactic frequently utilized by the Ostrogoths. Vittigis, for example, planned to lay siege by both land and sea to the Roman cities of Dalmatia. When laying siege to the city of Burnus, the Ostrogothic fleet anchored directly next to the city walls for a coordinated attack with land forces. In addition to engaging in direct warfare, the Ostrogothic fleet also fulfilled logistical duties for the army, which was a continual concern for the Ostrogothic government and included the timely and efficient shipping of troops and supplies. Essential foodstuffs, including wine, corn, and meats, were shipped from the dioceses directly to the armies, or to ports near their location. Theodoric, for instance, organized a shipment of grain via the port of Marseilles to the military personnel residing in the forts on the Durance River. Cassiodorus, in 533, ordered the Ligurians to send supplies directly to the army, but allowed them to organize the shipping details. Supplies required in the hinterlands were presumably transferred into smaller local boats for movement through the river systems.

The Franks

Frankish groups conducted sea raids along the western European coasts concurrent with the Angle and Saxon attacks that plagued Britain. Indeed, Frankish ‘pirates’ were reported to have operated in the North Sea as early as the 260s, and to have ventured on raids as far as the southern Spanish and African coasts a decade later. Historical sources claim they established and operated a maritime base in North Africa from around 260 to 272, by using the ships seized in Tarragona; and by the 270s, the Franks were certainly raiding settlements along the Gallic coast and infiltrating river systems to inland cities. Carausius (Maximian’s admiral) had the responsibility of defending the coasts of northern Gaul and southern Britain from the Frankish and Saxon raids, but was unable to deliver a decisive blow to the marauders until 287.

A particularly interesting account concerning the early use of ship technology by Franks involved one group settled in Thrace, who were relocated there after having revolted against the Romans sometime in the 280s. This small group captured Roman fleet vessels on the shores of the Black Sea and proceeded to raid the Libyan coast, with the raids culminating in an attack on the town of Syracuse.

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176 Ibid., 5.16.9-16.
178 Scriptores Historiae Augustae, “Divus Aurelianus,” 7.1-2; 33.3; Eutropius, Breviarium ab urbe condita, 9.21.
179 E. James, The Franks, p. 37; Aurelius Victor, Liber de Caesaribus, 33.3. Despite their string of successes, a group of Frankish raiders was defeated in 287 by Maximian after their landing: Nazarius, Panegyric to Constantius Chilourus, 18.3.
180 James, The Franks, p. 38.
Leaving Sicily, they entered the Atlantic Sea, presumably en route to the shores of northern Gaul.\textsuperscript{181} While it is probably true that a Frankish settlement was founded in Thrace by Probus (276-282), it is doubtful that a significant portion of a Roman fleet was appropriated by these renegade Franks. It is uncertain as to whether the garrisoned ships that were taken were warships and/or transports. In any case, only a few ships were likely taken and these vessels were assuredly sailed. Roman warships under oared propulsion without appropriately trained crews would not likely have affected a successful escape, and without the proper accompaniment of coordinated supply vessels, these oared warships would have required numerous stops.\textsuperscript{182} Roman oared-warships would also have been a poor choice for appropriation by the band of Franks if they had planned to return home by sea, as such a trip entailed the Atlantic route. Although the Atlantic route to northern Gaul could prove difficult to navigate for even well-trained crews, the Franks were apparently familiar with sailing this route for several decades. Attempts to use this account alone as evidence for both the weakness of the Roman navy and the talented seamanship possessed by the Franks, however, are unworkable. Foremost, there is a preponderance of evidence indicating a formidable Roman naval force that was active during the Late Empire and Late Antiquity. Insofar as using the passage as evidence for Frankish seamanship, uncertainties remain as to whether the Frankish settlers acted as crew, or simply commandeered the Roman crews along with the vessels. The events do, however, corroborate other accounts that the Franks were familiar with seagoing vessels and their operation over long distances throughout the third century. Furthermore, the Franks were possibly exposed to Mediterranean shipbuilding technology and seamanship skills in the third century. As Franks were conducting overseas raids throughout the North Sea region from the 260s onwards, their scrutiny of Roman naval technologies and skills were likely done with potential applications in mind.\textsuperscript{183}

Frankish raiders were active along the northern Gaul and Iberian coasts throughout the early fourth century.\textsuperscript{184} In 358, however, they were forced into a treaty through the campaigns of Julian. This treaty achieved what the Romans desperately required at this time, a cessation of Frankish raids on Roman shipping in the lower Rhine area that had disrupted logistical support efforts in the region.\textsuperscript{185} Such concessions are testimony to the effective use of naval operations by the Franks. This cessation of

\begin{itemize}
\item \textsuperscript{181} Nazarius, \textit{Panegyric to Constantius Chlorus}, 18.3.
\item \textsuperscript{182} Although warships would also have had sail, untrained crews would have been less efficient in their rowing strategies. When commandeering a ship, there was undoubtedly little time to load adequate supplies, such as water. Moreover, the storage capacity on board was significantly less than that of a sailing transport ship. On the other hand, a single landing and loading of supplies on a transport vessel would have provided weeks of supplies, and minimized the risks of capture on shore.
\item \textsuperscript{183} Scriptores Historiae Augustae, “Divus Aurelianus,” 7.1-2.
\item \textsuperscript{184} Nazarius, \textit{Panegyric to Constantius Chlorus}, 17.
\item \textsuperscript{185} Eunapius, \textit{Works}, 18.6.
\end{itemize}
aggressions was short-lived, as the Franks began raiding the coasts of northern Gaul by the early 360’s.  

Once established in Gaul in the fifth century, the nascent Frankish (or Merovingian) kingdom had borders to defend and lands to protect. This resulted in a shift in the use of military watercraft. Simple hit-and-run raids were no longer tactically as valuable. Instead, ships were required to fulfill the more supportive roles of supplying land armies in their defensive efforts against other Germanic raiders. Such was the case in circa 470 when the Saxons penetrated deep into Frankish Gaul, captured the city of Orleans, and set up bases on islands of the Loire River. King Childeric (464–481) defeated these Saxon strongholds by successfully carrying a considerable number of troops to the islands in river transports. With King Theudebert’s (533–548) Frankish naval capabilities also extended to fighting at sea, Hygelac’s fleet was defeated in a naval battle. Raiding vessels early in Frankish history would have been unsuitable for such sea engagements, and there is little doubt that the Franks utilizing new types of military vessels by this time. In all probability, these new seagoing warships were designed in some part on Roman prototypes they had faced for centuries. Even if seagoing warships were constructed in substantial numbers throughout Late Antiquity, the primary area of Frankish military naval operations, unlike their trading concerns, were limited to the North Sea. This was due in part to the military sway held by the Vandals and Romans, and to a lesser degree by the Ostrogoths, in the Mediterranean.

The Visigoths

Unlike the other Germanic and Scythian kingdoms, there is little direct evidence that the Visigothic kingdom used ship technology for military purposes. As a result, it is difficult to make definitive statements concerning Visigothic military seafaring, but some inferences can be made. The Visigoths shared a common heritage and close political links with the Ostrogoths, who, by virtue of their settlement in Italy, utilized ship technology on many levels. The early raids conducted by the Goths in the Black Sea, along with their trade links via the river systems to the north, provided an early exposure to ship technology and its associated applications. Whether the development of ship technology was continued during their migrations and subsequent founding of a kingdom is unclear. Their conquest and settlement of Iberia’s Mediterranean coastline placed them in possession of numerous large and active ports engaged in commercial activities, but lacking the military facilities inherited by the Vandals and Ostrogoths. Towards the end of the fourth century, Alaric offered to send five thousand troops from

186 Ammianus Marcellinus, *The Later Roman Empire*, 27.8.4.
187 This was made more feasible after the Romans had delivered a defeat to other Saxon forces on land. Gregory of Tours, *The History of the Franks*, 2.18–19.
188 James, *The Franks*, p. 104.
189 *Scriptores Historiae Augustae*, “Probus,” 18.2.
Italy overseas to North Africa as a show of support for Honorius (395-423). It is uncertain whether Alaric was capable of transporting these troops himself, or whether they were to be conveyed on ships supplied by the Romans. In all probability, these soldiers were transported via merchantmen, many of which were certainly visiting the southern and southeastern Iberian ports during this period.

The Visigoths held Septimania and Narbonne through the seventh century, albeit these two regions were divided by the Pyrenees, which rendered the coastal routes crucial in maintaining the unity of the kingdom. Fleets of transports and accompanying warships were not required to effect this unity. Rather, a sufficient number of private merchantmen on regular trade routes along the southern Iberian and Gallic coasts would have sufficed. Unchallenged Roman naval attacks indicate the lack of a Visigothic fleet, as when Constantius' blockade of the Visigoths in southern Gaul around 415/416 went unopposed. Also, Justinian continued the naval attacks on their southern territory during his campaign in 551. During the initial Roman invasions of Iberia and subsequent logistical support, there is no reference to naval resistance on the part of the Visigoths, as opposed to the sea operations and threats posed by both the Vandals and Ostrogoths. Admittedly, arguing from a lack of evidence is insufficient to substantiate such a contention, but it is consistent with a Mediterranean dominated by Vandalic, Roman, and Ostrogothic naval forces.

While it appears the Visigoths were probably unable to engage in significant military operations at sea, they would have needed to maintain some semblance of a defensive naval presence on their northern river systems. The Visigoths had acquired from the Romans a river fleet stationed at Garonne, and maintained it in an effort to counter the Anglo-Saxon and Frankish activities to their north and east. A letter written by Sidonius Apollinaris in the 470s and addressed to a friend serving in the Visigothic navy, suggests the presence of a fleet. This reference may well have been to the fleet stationed at Garonne.

Naval Tactics in Late Antiquity

Despite the classic depiction of naval warfare predominated by ramming tactics, ramming was, in all probability, not the primary tactic utilized by warship fleets of the Late Empire and Late Antiquity in the Mediterranean. The sum of archaeological, iconographic, and written evidence concerning ship construction indicates that river warships did not possess rams, and casts some doubt that it was a necessary feature of seagoing warships. This compilation of evidence suggests instead an increased use

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190 Olympiodorus, Works, 10.1.
191 Marcellinus Comes, Chronica, 2; Orosius, The Seven Books of History against the Pagans, 7.43.1; E. Thompson, The Goths in Spain, pp. 320-334.
192 Sidonius Apollinaris, Epistolae, 8.6
193 Ibid., 8.
of projectile warfare and the associated defensive screens along the sides of warships for protection from missiles. With the disintegration of the Empire into many kingdoms during Late Antiquity, and the subsequent scramble for limited resources, capital investment in military assets was a careful consideration. Ramming tactics were less economical than other strategies due to the high risk of damage and loss of naval assets. Ramming also necessitated a large contingent of ships working in concert, which, in turn, required the maintenance of several fleets of warships and highly trained rowers to practically control all regions of the Mediterranean. Not only does the available evidence indicate that fleets were comprised primarily of transports, but that the logistics and economics of maintaining several large fleets of warships would have been tremendous for the fledgling kingdoms and a contracted Empire. Furthermore, expenditures on large numbers of warships designed for ramming tactics would have been a difficult expense to justify during the third and fourth centuries onwards. Such tactics would have proved ineffective in dealing with small pirate and raiding parties, attacking coastal defenses, or for supporting operations by land forces.

During the course of Late Antiquity, missile troops and artillery played an increasingly important role in warfare. The Roman military possessed specific artillery brigades attached to the legions, such as the ballistarii (artillery units) sagittarii (archery units) and equites sagittarii (horse archer units). As early as the third century, Roman archers were boasting that the Germans' bare heads and large bodies presented excellent targets for their arrows and javelins. Missile troops were considered extremely crucial by the mid-fourth century and archaeological finds support their greater presence. Artillery weapons of the period included slings, slot slings, onagers, crossbows, ballistas, and the bow. Slavic groups were using short javelins and wooden bows armed with short, poisoned arrows, whereas Germans and Scythians utilized long bows of both wood and composite materials. It seems likely that the Vandals and Ostrogoths played an important role in the rapid development of artillery tactics in naval warfare, as they were very familiar with the tactical use of projectile weaponry that could be readily applied to fighting on water. Hence, these new kingdoms emphasized one of their traditional military tactics when integrating battle at sea into their technological knowledge base. Roman

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194 Maurice, *Strategicon*, 12.8.3-21; Vegetius, *Epitoma rei militaris*, 1.14-17, 2.2.15, 4.44; Agathius, *The Histories*, 3.21.4; Zosimus, *New History*, 2.50.2-3; Ammianus Marcellinus 16.2.5, 26.7.15; *Notitia Dignitatum*, Occ. 7.97, 41.23, Or. 7.43, 57, 8.46-7, 9.47.
196 For example 800 arrows were found at Housesteads fort in Britain. Welsby, *Defence of the British*, p. 118.
197 Maurice, *Strategicon*, 11.4.11.
198 This was particularly true of the Alans and Huns. The Alans were one of the major ethnic components of the ruling class of the Vandal Kingdom. Archaeological finds include iron and bone arrowheads and horn stiffeners. Elton, *Warfare in Roman Europe*, p. 63.
tacticians were probably utilizing projectiles to a greater degree already by the first century, as projectile warfare was making headway into ramming tactics as early as the Hellenistic period. The application of projectile weapons in Roman naval operations was further prompted by their use in Vandalic and Ostrogothic naval activities. During the Late Empire and Late Antiquity, the Romans faced groups of enemy warships firing artillery, small groups of raiding vessels or pirate ships, and enemies strategically positioned along the shores of rivers. Artillery attacks would have been considerably more effective than ramming in countering such threats.

Warfare with an emphasis on projectile weaponry offered increased potential benefits with diminished risks and costs. The ability to strike less formidable ships, or a small group of ships, from a distance with projectile weaponry would have reduced the potential for damage of, or loss to, ships associated with ramming tactics. Although warships could have been rendered ineffective during artillery engagements through the killing of soldiers/rowers, the opportunity to recover the vessel existed if the enemy were successfully driven back. Not only was the loss of ships potentially decreased, but the victor also had the benefit of boarding and seizing vessels during combat and/or capturing those out of commission after the battle.

Written accounts also refer to the use of projectile warfare as one of the predominant tactics on the sea and rivers during Late Antiquity. Such tactics were utilized, for example, in Belisarius' campaigns. During the siege of Sicily, he placed bowmen in high platforms at the top of the ships' masts, from where they could fire over the city walls. This was the tactic again employed while attacking Naples, although greater caution was taken due to the stiff Ostrogothic defense through the use of missiles.\(^\text{199}\) Maurice made the association of warships and artillery explicit by the sixth century when he insisted that ballistae mounted on the prows of vessels were effective in conflict, and that archers placed in fortified positions should be included on board as well.\(^\text{200}\)

Maurice also maintained that, due to an increasing unwillingness of the enemy to fight, winter was the best time of year to attack, and that in such campaigns dromons must be brought into position.\(^\text{201}\) These statements bring to the forefront two important points concerning tactics. Dromons must have been able to directly support land operations, which could only have been effectively performed through the use of shipboard artillery, and dromons were operating in winter when rougher seas made sailing more demanding. This lends support to the tactical use of artillery platforms, as ramming tactics would have been problematical to carry out in the more turbulent winter seas with vessels unable to be adequately propelled or maneuvered by oar, and formations not easily maintained. Artillery on board

\(^{199}\) Procopius, *History of the Wars*, 5.5.11-17.
\(^{201}\) Ibid., 11.4.
warships would have provided an effective support for soldiers on land, particularly from inlets, bays, and rivers, and were instrumental in providing protection when troops were required to build bridges or cross rivers. As bridge construction progressed and came within enemy missile range, warships with mounted ballistae were preferably brought up on either side to clear away enemy threats.²⁰²

The evidence delineating military formations at sea are scarce. According to Maurice, when warships on a river were about to engage in battle they drew themselves up into a line that stretched from bank to bank, thus eliminating enemy flanking maneuvers. If there were enough ships, multiple lines were formed to prevent engagements from the rear, with care taken that their oars did not hit one another.²⁰³ This particular formation must be in reference to attacking forces on shore or groups of enemy ships that were firing projectiles. Combined with artillery use, such a tactic would have been extremely effective on rivers. Additionally, there were no enemy riverine fleets to engage that would have necessitated ramming tactics. It is reasonable to assume that a similar tactic was employed at sea, where multiple lines of ships were formed to concentrate projectile fire, in formations that were sufficiently wide or maneuverable to prevent escape or flanking measures by enemy ships.

²⁰² Ibid., 12.8.21.
²⁰³ Ibid.
CHAPTER VII
CONCLUSIONS

Introduction

During the height of the Empire in the second and third centuries, distant areas of the Mediterranean and Europe were united by a single administrative structure, which supervised and maintained a well-developed infrastructure. These conditions promoted the dissemination of technology between disparate regions, significant among which was ship-construction technology. The principle technological transfer during the second and third centuries involved the shipbuilding practices of northern Europe being transmitted to the Mediterranean. This unified landscape was broken apart into disparate states in the fourth and fifth centuries. Despite the loss of a unified Roman Imperial backdrop, contacts through both conflict and trade ensured the continual transfer of ship technology between the various regions and states of Europe and the Mediterranean. The presence and contributions of the Germanic and Scythian kingdoms were crucial in the developments of ship construction and their tactical applications in warfare. These rival kingdoms, in opposition to each other and the Empire, provided an impetus that drove developments in ship design, construction, and maritime naval operations throughout Late Antiquity. Many of these developments would have otherwise taken a longer period of time to develop, or developed along an entirely different course, without the impetus provided through interstate competition.

General Construction Trends

Through the examination over time of individual structural and non-structural ship components, it is clear that the developments taking place in the Mediterranean were not all made along a smooth, incremental evolutionary path at a steady rate (refer to Chart 74 for the comparative timing of individual trends). While planking thickness and the cross-sectional shapes of hulls appear to have been gradually altered, the dimensions of mortise-and-tenon joints, overall vessel size, the use of screens, and certain decorative elements had a more punctuated period of change. Furthermore, changes appear to be differentiated along other parameters such as vessel size and geography. Smaller vessels appear to have deviated from purely shell-based construction earlier than larger vessels, and shipwrights in the western Mediterranean possibly favored a different arrangement of longitudinal support timbers than shipwrights from the eastern Mediterranean.

Roman contact with northern European cultures and the formation of the Germanic and Scythian Kingdoms were pivotal events in the history of shipbuilding. Haywood is correct in his assertion that distinctions made between the shipbuilding traditions in categorizing European ship
construction evidence have been too great.\textsuperscript{1} Examination of the Late Imperial and Late Antiquity data indicates that cross-cultural influences played a significant role in the region, rendering the overarching typological groups of 'Celtic', 'Germanic', and 'Mediterranean' traditions often too rigid in the analysis of larger developmental trends. During the height of the Empire, shipwrights and carpenters traveled throughout the provinces and carried their shipbuilding and woodworking skills with them; often exemplified in the ships or boats in which they traveled. Typically, as a result of military postings, Mediterranean craftsmen possessing a variety of skills were present throughout northern Europe. In all probability, some of these individuals returned to the Mediterranean region, and brought with them the technical knowledge to which they had been exposed. Likewise, individuals from northern Europe were stationed in military posts around the Mediterranean, some of whom assuredly possessed shipbuilding knowledge. Hence, during the Late Empire, there was great opportunity for 'Mediterranean' shipwrights to be exposed to the techniques of those building in 'Germanic' or 'Celtic' traditions.

Methods of ship construction observed in northern Europe provided solutions to problems encountered by Mediterranean shipbuilders who were reacting to the economic pressures of an Empire in political and economic decline, and individuals who had to operate on slimmer margins and increased risks associated with trading ventures. More economically viable ships were those that maximized cargo capacity, required less capital investment in wood and labor in their construction, and that may be lost in a more dangerous operating environment without breaking financiers.

The incorporation of the Britons and Germanic groups of Europe into the Empire during the first through third centuries provided an excellent environment for cultural exchange. Military service was one of the fundamental routes Germanic and Celtic individuals took that placed them in direct contact with Roman culture.\textsuperscript{2} Frankish mercenaries, for example, formed a major contingent of Constantius' (305-306) army during his attack and defeat of Carausius.\textsuperscript{3} This environment for cultural exchange had great implications for ship technology. In Britain, northern Gaul, Belgica, and Germania, Roman military personnel were often exposed to the techniques of Germanic ship construction. Roman contact with northern European river and seagoing vessels during the first through third centuries prompted developments in the construction of Roman military craft in Europe, and later in the

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\textsuperscript{1} J. Haywood, \textit{Dark Age Naval Power, A Reassessment of Frankish and Anglo-Saxon Activity}, p. 17.

\textsuperscript{2} The incorporation of these groups was not limited to the Empire proper. Under Carausius' breakaway state in Britain from 286-296, for example, Germanic groups including the Franks, Saxons, and Angles were heavily recruited into the military. As the defensive efforts of Carausius included sea and coastal operations, there was ample opportunity for the Germanic groups to observe Roman shipbuilding technology and its associated skills. This breakaway state was eventually once more subsumed into the Empire.

\textsuperscript{3} E. James, \textit{The Franks}, p. 38.
Mediterranean. Utilizing northern European techniques, Mediterranean shipwrights gained greater control of hull shapes through the use of thinner planks, iron fastenings (in lieu of numerous mortise-and-tenon joints), and, eventually, by having frames precede some planks in the construction sequence.

These influences were not one directional, with the Roman presence in northern Europe impacting shipbuilding there as well. Dramatically increased demand for the movement of trade goods, building materials, raw materials, and the movement of individuals undoubtedly affected the scale of construction in indigenous northern European craft. It is unlikely a coincidence that the first large transport craft in the North Sea such as the Blackfriars and Gurnsey vessels make their first appearance with the arrival of the Romans. It is also during the first and second centuries that indigenous-build river craft reach their maximum sizes in northern Europe. The impetus of Roman demands allowed local shipwrights to apply and develop their traditional construction methods to suit larger vessels. It was these larger vessels operating in the North Sea and on northern European rivers that provided inspiration for Mediterranean shipbuilders.

Beginning in the fourth century, invading and settled groups from eastern Europe created a medley of political demarcations across the once unified European and Mediterranean landscape. Presumably, agreeable political links would enhance the transfer of technology, while strained relations would hinder them. Thus, the political adversity that existed between the Eastern Roman Empire and Vandal North Africa, or Ostrogothic Italy, had the potential to decrease the frequency and effectiveness of cultural exchange between peoples in these areas for some technologies. However, the substantial volume of sea-borne trade that connected these states inevitably facilitated the transference of ship technology between them. Furthermore, the capture of ships, ports, and other facilities during the formation of the kingdoms provided a common base of technological knowledge.

Technological exchange is inimitably conducted in contexts where demands for organization and maintenance are appropriate for the existing social, cultural, and economic setting. Additionally, exchange depends on the medium of communication operating between cultures. From the second to the beginning of the fifth centuries, a common language, governing structure, and economic system created a cultural landscape favorable to widespread technological dissemination. Shipwrights selected aspects of construction, as possessed by foreign vessels, that best suited their needs or to solve their problems. In doing so they drew upon, and were limited by, a variety of cultural factors such as adherence to cultural traditions, their own abilities, cultural prejudices, and available materials. The massive, and predominately stable, Imperial superstructure, particularly under the annona system, provided a greater

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4 K. Greene, "How was technology transferred in the Roman Empire?" in Current Research on the Romanization of the Western Provinces, eds. M. Wood and F. Querioga, pp. 101-105.

5 For example, the common language of Latin facilitated the linking of the East and West.
amount of government subsidy for ship construction and shipping than was the case in Late Antiquity. Subsidies insulated a significant portion of shipping from a more competitive private market. In the fragmentary, and more economically competitive, landscape of Late Antiquity, ships continued to ply the seas and promote the dissemination of water transportation technology between cultural groups. Formal state attempts to prevent the transfer of shipbuilding knowledge demonstrate the ease with which ship construction techniques were disseminated, and that many groups were known to have had sufficient technological abilities to incorporate and employ shipbuilding methods. In the early fifth century, there was legislation that made it specifically illegal to overtly provide Roman shipbuilding technology to Germanic or Scythian groups.  

However, it is the very nature of ships to travel and thus to disseminate their technology over wide geographical areas.

With the confluence of technologies occurring, it is not surprising to find evidence of experimentation that employed a hybrid of North Sea and Mediterranean ship construction technologies and methods. The County Hall ship from the port of London, dating to the late third or early fourth century, presents an excellent example of ship construction utilizing such a mix of traditions.  

The dimensions of this ship were around 19 meters in length and 5 meters in beam. In many respects this vessel displayed hull features characteristic of North Sea craft such as having little deadrise amidships, and a full, rounded hold area.  

The ship was also constructed entirely of oak timbers with some iron nails used in its fastenings, traits typical to this region’s indigenous construction at this time. However, this vessel also possessed similarities characteristic of Mediterranean ship construction; these included edged-joined planks with pegged mortise-and-tenon joints, and the presence of a true keel and post timbers. This keel ran the full length of the ship as opposed to keel planks typical of northern European craft. However, it had a much lower aspect ratio (0.77) than any contemporary Mediterranean vessel likewise designed for shallow water navigation. Frames were fastened to the planks with trenails, and, although similar in size to those found in Mediterranean craft, the frames were spaced quite far apart as those typically found in northern European vessels.  

The County Hall vessel operated along the Thames River and assuredly utilized the Roman controlled trade and port facilities, especially those found at Roman Londinium. Roman military personnel and merchants traveling between the continent and the

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6 Codex Theodosianus, 9.40.24.
8 Marsden, Ships of the Port of London, pp. 112-127.
9 The spacing was nearly double that found in contemporary Mediterranean ships. Ibid., pp. 117-118.
island province would have provided a mechanism for communicating the indigenous, as well as hybrid, ship technologies to Europe and the Mediterranean.

The Mainz river craft comprise another group of boats that demonstrate a mixture of ship construction technology. These later craft were found along the Rhine frontier and were almost certainly built and operated under direct Roman military supervision. While Haywood argues that they represent a sharp break from earlier warship design, this may not be the most useful way to characterize these boats. The Mainz boats were rather the product of cultural contacts and technological borrowing taking place between Roman military patronage and shipwrights building in the ‘Germanic’ tradition. Although the cultural background of these Roman-employed shipwrights cannot be ascertained, it is possible that Germanic shipwrights built the Mainz vessels in their indigenous manner of construction or, alternatively, Roman shipwrights who had adopted many Germanic methods were involved in their construction. In either case, one finds a later example of construction traditions coming together.

Each vessel displayed construction characteristics typical of indigenous northern European vessels, such as keel planks, iron nail fastenings (no mortise-and-tenon joints), and widely spaced frames. However, they were constructed shell-first by using molds to hold the planking in place. After the hull was formed, the frames were inserted and attached, the molds removed, and the temporary attachment holes in the planks were filled. These vessels, utilized by Roman garrisons, represent an excellent example of a hybrid of both Germanic and Mediterranean traditions coming together in vessels used by the Roman military. There was undoubtedly numerous military personnel who spent some time along the Rhine and came in contact with such river craft that later traveled or were stationed in some part of the Mediterranean. Individuals having knowledge of ship technologies would have provided the vehicle for continued dissemination into the Mediterranean region.

By the beginning of the sixth century, this dissemination had at least reached the eastern Mediterranean. The Tantura A vessel, dated to c. 500, possesses some of the fundamental characteristics of northern European craft; these include a lack of mortise-and-tenon joints, the use of iron nails for frame-plank fastening, at least some frame-futtock scarfing, the attachment of each frame to the keel, and the caulking of planking seams. Characteristic Mediterranean construction traits included utilizing a keel and posts, soft wood planking, multiple planks per strake, and the employment of a hook scarf. Though no temporary form attachments were detected, some type of form that did not leave evidence may have been used to initially hold some of the planking in place. It is also possible that some of the frames preceded the planking and others were later added. In any case, the mixing of traditions had reached the

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11 Personal communication with Dr. Cemal Pulak, November, 2001.
Mediterranean. As it unlikely that the Tantura A was the first vessel to utilize a hybrid of methods and construction features, such experiments in ship construction were probably taking place in the fifth century, precisely when the new Germanic and Scythian kingdoms had formed on Mediterranean shores. These kingdoms were composed of amalgams of groups, some of which assuredly possessed individuals familiar with the ship construction methods and features from northern Europe.

A particularly strong piece of evidence demonstrating a northern European influence on Mediterranean construction is the rather sudden adoption of thinner hull planking. One line of reasoning contends that the thinning of hull planks over time was a by-product of the shift from shell constructing to attaching some frames before the planking was completed. The fundamental basis for this hypothesis was that increased labor costs forced the abandonment of mortise-and-tenon joints, and promoted the shift to frames preceding planks. Thinner hull planks were then feasible, as thicker planking was no longer required to accommodate large mortise-and-tenon joints. Although some elements of this hypothesis are valid, it places the reduction in planking thickness in a subsidiary role and fails to adequately explain this decrease over time. Not only did the preceding of frames to planks not necessitate a decrease in planking thickness, but planking thickness was already decreasing prior to the decrease in sizes of mortise-and-tenon joint and before any significant installment of frames before the fastening of planks. More importantly, the thinning of hull planking did not follow the same pattern over time as that of decreasing mortise size as would be expected. Both mortise size and planking thickness were gradually decreasing from the second through fifth century, planking thickness began a drastic decrease in the sixth century, and continued into the seventh century, while mortise size had reached a relative minimum size by the sixth century. Thus, the trends did not correspond so that smaller mortises allowed thinner planking, rather some other factor allowed a greater decrease in planking thickness after mortises had already reached their minimum dimensions. Primary among the changes that takes place contemporaneously with the sudden decrease in planking thickness were an increase in the number of frames attached to the keel in the sixth century and an increase in the dimensions of longitudinal support timbers beginning in the fifth century. These changes provided increased hull strength that would have been lost by utilizing thinning hull planks, and also importantly, that would have been lost when no longer inserting tenon pegs.

An alternative hypothesis, based on the detailed analysis of the available evidence, places the impetus for change on the broader socio-economic considerations of a reduction in investment and maintenance costs while increasing operating revenues, and the consequences brought about from new cultures entering into and governing portions of the Mediterranean world. Hence, the reduction in planking thickness, the decrease in mortise-and-tenon joint size, and their eventual relegating to the role of alignment, were part of a conscious effort to effect changes in the design of hull shapes and to reduce
the amount of wood, labor, and time used in the construction and maintenance of hulls. Ship construction appears to have been influenced by several simultaneous trends: decreased overall hull weight, increased control over hull shape to create box-like cross sections to maximize hold space, a reduced demand on timber resources, decreased production time, diminished labor input, and increasingly simplified repairs. The reduction of planking thickness was essential to enable the bending of strakes in the formation of boxier hulls. Although plank thickness was reducing throughout the third and into the fourth century, mortise-and-tenon joints had to be reduced in size to allow further reduction. The solutions to these problems focused on attaching thinner planks directly to some pre-erected frames, a technique found among the northern European traditions.

A consequence of these developments in Mediterranean ship construction was that ships of the later portion of the period of study had shorter life spans than did ships from earlier in the period. A primary reason for this was that the materials, fastening, and construction methods produced less durable vessels. However, it was not the durability that was in issue, but the investment costs. It necessitated less of a capital investment to construct vessels later in the period. This was an important consideration for operators from the fifth century onwards because there was an increase in the risk for ship operation in the Mediterranean. The probability that vessels would reach their natural operational lifespan was less in the fifth through seventh centuries due to an increased presence of hostiles at sea and along shores than in earlier periods. Hence, reducing the investment costs of ship construction also reduced the potential loss.

Design and Planning in Ship Construction

Over the course of Late Antiquity the methodology, and indeed philosophy, of ship construction was undergoing a transformation. Vessels were becoming lighter, less labor-intensive and costly to build and maintain, and increasingly boxier in their cross-sectional shapes. To achieve these hull shapes, strakes were aligned off the keel at low angles of deadrise. However, in forming this shape, it was also necessary to produce harder turns at the bilge and greater bending of the planking at the extremities of the vessel. Shipwrights must have had an underlying conceptualization in the design stage of hull shape in order to form these novel shapes. In order to consider the degree to which shipwrights were engaged in the planning and design of their projects, the level and application of simple mathematical knowledge and measurement methods utilized by craftsmen, such as shipwrights, in Late Antiquity must be addressed.

Every aspect of a construction project, from the design and financing estimates, to material selection and work supervision, typically was under the responsibility of engineers in Roman society. In a similar manner, the responsibilities of shipwrights, who were versed in different crafts and types of materials in addition to the practical skills of ship construction, included the selection and acquisition of
the appropriate raw materials. Engineers and shipwrights could work on a range of projects that might vary greatly in size and complexity the former overseeing architectural projects ranging from a simple roadway to a basilica, and the latter, constructing vessels ranging in size from coastal lighters to large cargo carriers or warships for the fleet.

Vitruvius’ description of an engineer’s ideal education reflects the wide variety of skills and training required during the Imperial period:

Let him be educated, skillful with the pencil, instructed in geometry, know much history, have followed the philosophers with attention, understand music, have some knowledge of medicine, know the opinions of the jurists, and be acquainted with astronomy and the theory of the heavens...he must have a knowledge of drawing so that he can readily make sketches to show the appearance of the work which he proposes. Geometry, also, is of much assistance in architecture, and in particular it teaches us the use of the rule and compasses, by which especially we acquire readiness in making plans for buildings in their grounds, and rightly apply the square, the level, and the plummet...It is true that it is by arithmetic that the total cost of buildings is calculated and measurements are computed, but difficult questions involving symmetry are solved by means of geometrical theories and methods.12

Vitruvius was clearly advocating the highest ideals of an engineer, and certainly each attribute of an engineer was not necessarily required of a shipwright. His description demonstrates, however, that as early as the first century BCE a sufficient degree of mathematical sophistication and technical drafting was utilized in the design of, and measurements for, architectural projects.13 Engineering as an occupation survived into Late Antiquity, as they were commonly present as court officials into the fifth century.14 The designers and overseers of Justinian’s church of St. Sophia, for example, were referred to as “engineers”, there being no designation for an “architect” at this time. As with earlier engineers, these individuals held a wide variety of design and construction duties, and were required to have a broad base of technical, scientific, and cultural knowledge.15

Technological and scientific knowledge was fluid in its dissemination during the Late Empire, and after the formation of the Scythian and Germanic Kingdoms, it continued to be communicated over wide areas. Engineers traveled a far and wide throughout the Empire and western kingdoms, spreading

12 Vitruvius, The Ten Books of Architecture, 1.3-4.
13 The costs of projects were also preplanned before construction, a task that would have also been necessary for shipwrights building for others who financed construction projects.
14 R. Krautheimer, Early Christian and Byzantine Architecture, p. 68.
15 L. Rodley, Byzantine Art and Architecture, p. 67.
their knowledge and assimilating new ideas when interacting with other craftsmen or technologies. Evidence from major cities of the western Empire in the fourth century indicates engineers of large architectural projects had traveled from outside areas, many from the East.\(^\text{16}\) Also, there was the passing of architectural plans between workshops within the Balkans and the circulation of architectural plans throughout different cities of the Empire as early as the fifth century.\(^\text{17}\) Imperial military construction throughout the provinces also fostered the movement of engineers and the associated dissemination of their technologies, a propagation that continued into Late Antiquity. The military campaigns of the sixth century enabled engineers to travel widely with the civil and ecclesiastical administrations. Both the art and architecture of the period demonstrate inter-regional influences in addition to those that existed between the metropolitan and provincial areas.\(^\text{18}\)

Architectural projects remained stationary and therefore required inquisitive craftsmen to travel to construction sites in order to observe examples of new technology, while ships traveled from place to place, often over long distances. Even so, some shipwrights undoubtedly traveled widely as engineers. Shipbuilding technology would have thus been one of the most widely disseminated technologies, providing numerous options and innovations from which shipwrights in different regions could select in solving particular problems. A variety of reasons prompted maritime travel in the Imperial period, not least of which were trading ventures and military operations. Each of these necessitated the accompaniment of craftsmen to repair and maintain watercraft. Considering the innovation and dissemination of mathematical applications in design and construction throughout a wide geographical area, it is improbable that shipwrights would have remained insulated from such knowledge for centuries.

There were other aspects that served to link the careers of engineers of architectural projects and shipwrights. Carpentry was the primary skill involved in shipbuilding, a skill also invaluable in architectural construction. As concrete was increasingly incorporated into building projects, there was an increasing demand for carpenters to build the forms for domes and vaults. These carpenters were supervised by engineers, who were required to impart some of their design and construction principles when instructing carpenters. Inevitably, carpenters working on both architectural and ship construction projects created the opportunity for the sharing of design and construction ideas between the two disciplines. Moreover, it seems probable that the similar professional requirements of engineers and shipwrights would have instigated contact between the two while selecting wood at timber yards, buying tools from smiths, or during the organization of architectural building materials that required shipping.

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\(^{16}\) Krausheimer, *Christian and Byzantine Architecture*, p. 68.

\(^{17}\) Rodley, *Byzantine Art and Architecture*, p. 54.

\(^{18}\) Ibid., pp. 112-113.
Utilizing mathematics in design and construction also required the practical ability to measure dimensions and angles. Measuring was a process that utilized simple equipment, requiring the most rudimentary of operational skills. Graduated sticks, ropes, and wheels were all used for measuring distances, while plumb bobs and squares were available for determining angles. There are numerous examples of architectural projects that demonstrate the use of measuring systems in design and construction (Chart 69). In some vessels, planking timbers appear to have been cut to a predetermined thickness in at least two measurement systems (Charts 43-45) with a value of 1.75 uncii and a value of 1.5 uncii-Drusus being the most common.\(^{19}\) It is difficult to determine what particular measuring system or systems ship builders used, in part due to the inherent problem in determining where any particular vessel had been built.\(^{20}\) It should also be kept in mind that a variety of measuring systems were used within the same area, such as with structures in the same city. The church of S. Agata dei Goti in Rome (462-470), for example, was conspicuously laid out in Byzantine rather than the more commonly used Roman feet found in the city’s buildings, as were other contemporaneous structures.\(^{21}\)

Measurement systems enabled not only design planning, but also a degree of standardization of that design. The uniformity of architecture on a regional level, presumably resulting from the influence of prominent engineers, is evident from the imitations of the plan for the triconch cemetery chapel near Carišin Grad, Yugoslavia.\(^{22}\) This design, with the associated measurements in Byzantine feet, was subsequently transferred for use in the funerary chapels at Kuršumlija and Klisura. Other trends convey an architectural homogeneity beyond the influence of a single engineer. During the fifth century, quasi-standardization existed for the plan dimensions of naves of churches in the Roman West, these having measurements of approximately 50 x 150 x 60 Roman feet. In a similar example of standardization, fortresses constructed at the beginning of the sixth century were usually square or rectangular in their ground plan and tended, on average, to measure 188 x 250 Byzantine feet.\(^{23}\)

Using standardized measurement systems and pre-construction designs enabled shipwrights and financiers to more accurately predict the potential profits and costs of projects. This was a crucial factor in capital investment decisions in the more competitive economic environment of Late Antiquity. The state, as well as the individual investor, benefited from a standardized measurement systems. A degree of

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\(^{19}\) Although it is difficult to ascertain if a measurement system was used, all measurements that correspond to a unit or fraction of a unit in a system cannot be coincidental.

\(^{20}\) However, the Serci Limanı vessel, dated to the early 11th century, was laid out in Byzantine feet: J. Steffy, *Wooden Shipbuilding and the Interpretation of Shipwrecks*, pp. 85-91.

\(^{21}\) However, this is another good example of the wide-regional interaction of engineers and thus their associated technologies and skills: Krautheimer, *Christian and Byzantine Architecture*, p. 174.

\(^{22}\) Ibid., p. 170.

\(^{23}\) Ibid., pp. 258, 275.
military equipment, such as helmets, javelins, swords, and armor, were subject to standardization to minimize costs and facilitate training. It is logical that standardization would have benefited all areas of the military including naval forces, and thus attempts were made to achieve greater uniformity associated with maritime assets. Standardizing warship dimensions would have been a relatively simple task for shipwrights utilizing a measurement system and some type of pre-planning of dimensions during their design and construction phases. Such systems would have allowed for more accurate planning and budgeting for financial outlays on warships and transport vessels. This was a crucial consideration for the smaller, and fiercely competitive, Mediterranean states of Late Antiquity. With a uniform warship design, troops could be trained in basic skills that would be applicable to any vessel to which they were assigned. Regularized training programs for troops on oared galleys would have greatly increased the efficiency and flexibility of personnel assignments. Furthermore, it would have allowed the inter-changing of equipment and fittings between vessels of like design, facilitated repairs, and potentially resulted in a greater number of ships available for action.

Another noteworthy observation arises from a comparison of ship construction with architecture in Late Antiquity. By mid-sixth century, a change occurred in the dominant style of large-scale architecture that included an increased employment of square-domed bays and double-shelled plans.24 The resulting novel trends demonstrated the expanding abilities of engineers as they dealt with increasingly complex structural and architectural demands.25 These designs incorporated lighter vaults that enabled bolder skeleton construction, with wider vaulting spans that featured fewer and thinner supports.26 Inherent in these innovations was an understanding of weight distribution and forces in relation to structural design. A contemporary parallel between architecture and ship construction is evident insofar as the shells (domes in architecture and hull planking in ships) were becoming lighter, which enabled greater control of shape and size, while support was shifted to internal components (ribs in architecture and frames in ships). These developments demonstrate analogous and contemporaneous technological developments in both architecture and ship construction, based in some part on the application of mathematics in design. Engineers, carpenters, and shipwrights operating within similar technological environments and with similar materials experienced comparable developments, and assuredly approached these developments with similar manners of planning and design.

24 Paradoxically, both of these innovative elements were being applied to structures whose other design and structural elements were in the midst of a static period.
25 Rodley, Byzantine Art and Architecture, pp. 64-71.
26 Krautheimer, Christian and Byzantine Architecture, p. 228-229.
Factors in the Development of Ship Construction

Naval construction trends during the Late Empire and Late Antiquity in the Mediterranean were driven by the shipbuilders' and operators' attempts to increase the economic efficiency of vessels through a reduction in material inputs and labor, while enlarging available hold space. Lighter, roomier hulls could carry an increased cargo without significantly impinging on speed, if at all, which resulted in more profitable ventures. Furthermore, heavy cargos sitting in a lighter hull lowered the center of gravity and provided some increased stability benefits. These trends in ship construction were occurring concomitantly with similar developments in the design and manufacture of amphoras. Over time, amphoras developed a higher volume to weight ratio that resulted in a greater portion of the cargo weight devoted to the actual trade goods rather than to the container, and hence greater potential profits for each shipment. Additional hold space per unit length of ship in vessels by the sixth and seventh centuries allowed the stowage of a greater quantity of amphoras (or bulk cargos such as grain) than in vessels from earlier in the period. The combination of increased hold space with the more efficient amphoras yielded an even greater potential for transporting actual produce in ships at the end, compared to the beginning, of the period. Either greater quantities of goods could be shipped during Late Antiquity than in earlier periods, or smaller vessels from the end of Late Antiquity could carry similar quantities of cargo as was carried during the late Imperial period. Therefore, the general reduction in the size of vessels in Late Antiquity did not necessarily entail a concomitant decrease in cargo quantity. Consequently, the degree to which overall trade decreased during this period may have been overestimated. Such trends beg the question as to why overall ship size decreased if ships were more efficient. It is logical that utilizing larger ships that carried more cargo would have further increased the profit potential, but there remained upper limits on the amount of capital investment and the associated degree of risk willing to be assumed for a given venture or individual craft. An increase in the amount of trade goods carried on a vessel consequently increased the potential loss of capital investment in and profit from the cargo, if the vessel was sunk or commandeered. The rival states of the Late-Antiquity Mediterranean heightened the risk for merchant ventures, above that stemming from piracy alone during the Late Empire. Smaller and less costly vessels were more versatile in their economic applications, had better maneuverability for eluding enemies, and by distributing the cargo between several smaller vessels risk was minimized. Merchant, state, and church ventures utilizing smaller ships that required less capital investment, but nevertheless transported a comparable amount of cargo, were thus able to improve the overall economics of weighing investment and risk to potential gain. Such considerations also hold for redistributive concerns, such as those associated with military logistics, in that managing costs, risk, and efficiency were crucial to successful operations.
Traditional arguments for the motivating factors in the development of ship technology throughout the Late Empire and Late Antiquity have primarily centered on labor availability and investment costs. Imperial ship construction has been postulated as a high-labor investment made feasible by the supply of slave labor, although innovation was restricted as a consequence. Thus, the decline in slave labor associated with the fall of the Western portion of the Empire resulted in innovations that reduced labor requirements and expenditures. Although a neat, simplistic, and attractive argument, it contains several flaws. The institution of slave labor was not an adequate condition in itself to prohibit technological advancement. It is also difficult to determine the operating costs of slave versus non-slave labor in association with shipbuilding, as slaves were costly to buy and maintain. Continuous support of a slave required funds for their feeding, housing, medical attention, stipends, etc., which represented significant costs for owners. Whereas contracted labor could be purchased on a project-by-project basis. It is entirely possible, therefore, that skilled slaves required for ship construction constituted a greater expense than would free skilled craftsmen. Slaves were most economical when employed on large-scale projects that incorporated a host of unskilled tasks such as harvesting, road construction, and some aspects of architectural construction.

Another problem associated with arguments founded largely on labor cost and supply is that little evidence exists to support a sudden and dramatic decrease in slave labor during the third century, at which time the changes in ship design and construction underwent some of the most fundamental transformations. It is also uncertain as to the role slave labor played in the ship construction industries of the later Germanic and Scythian kingdoms. For all practical purposes, the ability to curb labor costs was independent of the slave labor supply, in that reducing the number and/or time employed on a given project by craftsmen, whether slave or nonslave, resulted in more profitable ventures.

The primary savings in labor were in large part due to the decreased utilization of mortise-and-tenon joints, the most time-consuming tasks in building ships. Having to cut tenons so that they fit flush within their mortises, as well as align two opposing mortises exactly, a characteristic of edge joints up to the third century, required a great deal of skill and time. Once mortise and tenon sized decreased, tenons were no longer required to fill their mortises entirely, and approximations were made in both tenon size and their alignment within opposing mortises, there were fewer potential savings in labor hours as the foremost area of reducing labor requirements had already been addressed. Although the use of tenon pegs were discontinued in joints by the fifth century, the resultant labor savings were relatively small in comparison to other areas. With fewer, smaller, and less exacting mortise-and-tenon joints employed,

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28 This holds for joints that were pegged or unpegged.
one or two persons could conceivably handle the production of tenons and pegs for most vessels of the late fourth century onwards. Hence, the primary developments in ship construction that impacted labor hours were realized by the third/fourth century, and relatively little impact on labor time was associated with developments during the subsequent centuries. The trends continued to impact the cost of projects, in that ships could conceivably have been built at a faster rate. With key frames in place, and few mortise-and-tenon joints to cut, planks could more rapidly be nailed or treenailed into their positions. Hence, the time workers needed to spend on a given project may have been decreased. Cost savings over the period were also realized through a reduction in the total amount of timber necessary for a project, particularly in the amount of long, straight timbers required for planking. Thinner planks would also have taken shapes more readily than thicker ones, requiring less fairing and shaping by hand that added to labor costs. Additionally, more planks could be cut from a given log, thus a concomitant decrease in the transportation of raw materials and delays in adequate timber supplies were potentially reduced.

From the first permanent contacts with Rome in the first century, northern European traditions of ship construction influenced the conventional shipbuilding traditions of Mediterranean shipwrights. At the same time, the magnitude of the Roman economic system and demand for resources from Roman military presence increased the scale of vessel sizes in northern Europe and the North Sea. Furthermore, the construction of larger vessels impacted the development of indigenous ship construction as well. The first watercraft that exhibited a definitive mix of early northern European and Mediterranean characteristics were built during the third to fourth centuries,29 these being Roman ships found along the Thames and Rhine rivers respectively. The populations residing in these regions had interacted for centuries, primarily through the establishment of large military bases, and were engaged in construction activities that were often directed by the Roman military.

The earliest evidence of hybrid vessels integrating both indigenous and Roman methods of construction occurs in Britain during the third century, and the phenomenon reaches the continent by the fourth century in river vessels found along the Rhine.30 Although much of the Mediterranean world had been cut off from easy direct access to the North Sea at the beginning of the fifth century, European river vessels, similar to those of the third/fourth centuries, would have continued to stimulate technological

29 Later northern European building of seagoing vessels was dominated by lapstrake construction.
30 One of the fundamental characteristics of early northern European ocean craft and some river vessels was that planking had been attached to pre-erected frames. These were small craft such as the County Hall and Mainz River boats, both built with a mixture of Germanic and Mediterranean methods. This is not to say that all frames preceded all planks, rather that planks were attached to molds that were already attached to the hull; this could have been done in a step-by-step manner as well: Marsden, Ships of the Port of London, pp. 112-127; O. Höckman, “Late Roman River Craft from Mainz, Germany,” in Local Boats: Fourth International Symposium on Boat and Ship Archaeology, Porto 1985, ed. O. Filgueiras, pp. 25-32.
development in the Mediterranean during the following centuries. By the fifth and sixth-century, it is evident that methods utilized in the third to fourth century European river craft were being exploited in the construction of ships of a similar size in the Mediterranean. In the Mediterranean, the differentiation in size between mortises and their tenons began in the fourth century simultaneously with the first experimentations of placing some frames in the hull before completing the outer planking. Several centuries of technological dissemination perpetuated by shipwrights working on the rivers along the eastern European border, whether Romans or under Roman supervision, resulted in these hybrid vessels in the Mediterranean by the sixth century, and most likely a century earlier. Predictably, innovations in the Mediterranean were initially expressed on a smaller scale, the earliest example to date being a small coaster dated to circa 500 whose dimensions were similar to the hybrid northern European river craft of the third and fourth centuries. This hybrid vessel was found in the region of the eastern portion of the Roman Empire, the only surviving portion at the beginning of the sixth century. It is reasonable that these developments would have occurred here, in a more stable and continuous cultural region, as other portions of the Mediterranean had undergone drastic cultural and political upheaval. Although frames did not precede planks at this time in the largest merchantmen, this method was beginning to be utilized to some degree in larger merchantmen by the sixth/seventh century.

Despite the fact that influences were derived from early northern European construction methods, they were not adopted wholesale, and Mediterranean ships were not exact replicas of craft seen in the northern Europe or the North Sea. Mediterranean shipwrights retained various aspects of their own shipbuilding traditions, such as the use of treenails to connect frames and planks, the incorporation of a keel and keelson, employing closely spaced and smaller frames, the attachment of multiple wales, seating stringers atop the frames, and, for a short period, the use of mortise-and-tenon joints. These established construction attributes were fused with novel design and construction methods to form the ships of Late Antiquity.

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31 Although an overall size reduction of these joints was already underway by this time.
Merchantmen and Warships in a Changing Mediterranean

During the Late Empire, a vibrant Roman economy was maintained in part by the large amount of overseas, coastal, and riverine traffic conveying trade goods. Combined with a widespread road system, the Empire was highly integrated, allowing the efficient movement of people and commodities to distant areas. With the elimination of enemy fleets throughout the majority of the Empire, Roman naval assets were used to ensure a relatively safe environment for merchants at sea and along river systems during the Late Imperial period. The fleets' other main duties during this time included the transportation of officials, troops, materials, supplies, and the maintenance of communication, over great distances; their ships were proficient instruments for responding to conflicts. Thus, Roman fleets were comprised primarily of transports. Although the Mediterranean was relatively peaceful during the Imperial period, territories situated on the North Sea frequently endured maritime raids. These incursions, in conjunction with substantial land assaults, eventually broke Roman control in northern Europe.

With the loss of northern Europe and the western Mediterranean, the Roman Empire was confined to an area centered on the eastern Aegean and the western portion of the Black Sea. Overseas trade was now particularly imperative for the survival of the Empire's economy considering its more isolated position. Even with its resource base constricted, the Empire's expenditures on naval assets did not apparently decrease, but in all probability increased. It was crucial for the Empire to maintain a strong naval power to ensure its ability to trade overseas, and guarantee its survival in the new community of hostile states in which it now resided. During the fifth century, the emergent naval powers of the Vandal and Gothic kingdoms provided a direct challenge to Roman maritime hegemony, and therefore its economic and political fortunes.

Foremost among those challenging the Romans for control of the seas was the Vandal kingdom. Their capture of Roman military and merchant vessels, in addition to associated port facilities, enabled the Vandals to rapidly become a significant maritime power in the Mediterranean. The Vandals not only exercised their maritime prowess through military might, but also cultivated a bustling Mediterranean-wide trade network. The Ostrogothic kingdom, arising from the ruins of the Western Empire in Italy, presented a similar maritime threat in the Mediterranean. Like the Vandalic kingdom in North Africa, the Ostrogoths inherited numerous port facilities, craftsmen skilled in ship technology, and active trading cities along the Italian coasts. These trading centers continued to be active in overseas trade throughout Late Antiquity. In addition to private mercantile ventures, Mediterranean ship technology was also employed in the construction of vessels for Ostrogothic military operations. Pressures from Roman and Vandal maritime operations along their coasts forced the Ostrogoths to make an investment in their own military fleet. Although their naval resources provided a limited protection, and were engaging in
regular overseas offensive operations, they never reached the scale of their Mediterranean adversaries. In contrast to their Gothic cousins, the Visigothic kingdom did not apparently invest, to any significant degree, in naval assets. The majority of ship technology associated with the Iberian kingdom was instead employed in overseas and riverine merchant trading. The Frankish kingdom also conducted a great deal of overseas trade, and received the brunt of considerable raiding activity. Eventually, they were forced to cultivate enough naval force to provide some defense to these raids and safeguard their trading ventures. However, their naval forces remained defensive in nature, and did not appear to have regularly been employed for overseas offensive campaigns, or have risen to a level that posed a significant threat in the Mediterranean. Instead, the Franks engaged in active trading throughout the North Sea and river systems of Gaul. Their comparatively meager fleet was sufficient to repel invasions and protect their merchant operations. Although each kingdom was engaged to some degree in sea warfare, the primary objective of fleets remained the transportation of land forces to campaign areas. The ultimate result of these competing naval powers was an increasingly dangerous sea on which ships operated, and abundant hostile shores along these waters.

Due to the dearth of archaeological remains, the characteristics and tactical usage of Late Antiquity warships must be gleaned from iconographic and historical sources, and supplemented with data from terrestrial excavations. An examination and synthesis of warship iconography from the second through seventh centuries suggests that alterations were taking place in warship design, the outfitting of vessels, and possibly the tactical and strategic use of military craft. It appears that by the third century, warships began to decrease in size, probably in conjunction with their shifting tactical roles and due to factors inherent in economic trends. The disappearance of standard, and a decline in the use of various decorative traits on warships, as revealed by depictions after circa 250, may reflect the changing military priorities during the late Imperial period. Chief among these priorities for the Empire was a strategic shift from operational areas near the Mediterranean to those in northern and eastern Europe. Having no enemy state and only piratical foes to confront within the Mediterranean, Roman fleets were principally engaged in providing support for operations further north during the Late Empire. It would not be until the beginning of the fifth century, with the emergence of the Germanic and Scythian maritime powers, that a more forceful military presence was required in the Mediterranean.

Warships were almost certainly undergoing modifications in their construction similar to those in merchantmen during Late Antiquity. These construction developments included a decrease in planking thickness, a reduction in the size and frequency of joinery used within hull strakes, and a concomitant increase in the robustness and integration of internal hull timbers. These trends have several economic motivations, such as the reduced capital investment and maintenance costs for vessels, but they would also have been prompted by changing naval military tactics that featured a greater
reliance on projectile weaponry. These construction and design modifications would have been advantageous in the quest for greater warship speed. With fully-decked warships, a decrease in planking thickness would have been most beneficial in decreasing vessel weight. A reduction in planking thickness also allowed increased control of hull shapes, and permitted warships to be built with sharper entries and exits, extended flat-runs along the sides, and required less transitional length from the ship's full beam to its posts. Lighter hulls with finer entries and sides with longer dead flat sections would have increased the potential speed and range under oar, or required fewer rowers to be used. A decrease in overall hull weight may have exacerbated a distinct problem associated with oared galley, in that the rowers were located high in the hull, which resulting in raising the center of gravity and decreasing stability. Limiting the level of rowers to a single bank, as occurred in Late Antiquity, would have been a prudent measure in dealing with stability issues, as would have decreasing the length-to-beam ratios of warships.

Contrary to oft-repeated themes, the fully-decked warships of the Late Empire and Late Antiquity, as evidenced by iconographic and historical sources, were overwhelmingly depicted with a single level of rowers. From the beginning of the fourth century, there also appears to have been a sharp increase in the number of defensive screens present on warships. These characteristics, in conjunction with written accounts of naval military operations and the potential advantages provided by shipbuilding trends in the Mediterranean, suggest that projectile weaponry and boarding tactics were becoming increasingly prevalent in naval engagements as opposed to the ramming tactics proposed for earlier periods. Full decks would have served to protect the rowers from missile fire, while defensive screens protected soldiers at deck level. Smaller, lighter, and faster warships would have been better suited to the tactical requirements of projectile warfare than those of ramming. These tactical modifications were undoubtedly a direct result of the political divisions within the Mediterranean during Late Antiquity. The Roman maritime hegemony was broken by the aggressive maritime activities of the nascent Germanic and Scythian kingdoms. The Vandals, Goths, Visigoths, and Franks applied tactics familiar in their terrestrial warfare to their utilization of fleets, thereby altering the course of warship development in the Mediterranean. By the seventh century, warships and merchantmen had undergone significant and somewhat rapid changes in their construction and design, and set the stage for the great Byzantine and Arab fleets that were to soon explode onto the scene.
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APPENDIX A

CHARTS

Chart 1. Estimated Lengths of Mediterranean Seagoing Vessels

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<th>Wreck site</th>
<th>Date</th>
<th>Est. Lgth.</th>
<th>Century</th>
<th>&lt;= 20 m</th>
<th>&gt; 20 m</th>
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<tr>
<td>Punta Scifo</td>
<td>c. 200</td>
<td>30-35</td>
<td>4th</td>
<td>5.5</td>
<td>0</td>
</tr>
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<td>Bourse de Marsaille</td>
<td>c. 200</td>
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<td>5th</td>
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<td>1</td>
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<td>c. 215</td>
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<td>6th</td>
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<td>12-15</td>
<td>7th</td>
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<td>13-15</td>
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<td>Yassi Ada</td>
<td>4th</td>
<td>19</td>
<td></td>
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<tr>
<td>Dramont E</td>
<td>4th</td>
<td>10-12</td>
<td></td>
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<tr>
<td>Laurons 3</td>
<td>4th</td>
<td>12-15</td>
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<td>c. 415</td>
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<td>Tantura A</td>
<td>6th</td>
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<td>Anse St. Gervais</td>
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<td>Yassi Ada</td>
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Chart 3. Length-Beam Coefficients of Mediterranean Seagoing Vessels

Average = 3.05  Standard Deviation = 0.48

Vessels in Chronological Order
Chart 4. Length-Beam Coefficients in Relation to Estimated Vessel Length for Mediterranean Seagoing Vessels
Chart 5. Length-Beam Coefficients of River Vessels

Vessels in Chronological Order
Chart 6. Length-Beam Coefficients of River Vessels by Geographic Area of Deposition

Vessels Chronologically Ordered within Geographical Groupings
Chart 7. Average Keel Aspect Coefficients of Seagoing Mediterranean Vessels
Chart 8. Plot of Average Keel Aspect Coefficient to Estimated Vessel Length for Seagoing Vessels
Chart 9. Coefficient of Average Keel Aspect Coefficient to Estimated Vessel Length of Seagoing Vessels

Vessels in Chronological Order
- Monte Carlo
- Super Yacht
- Hellepola
- Vanda 1
- Vanda 2

Keel Aspect Coefficient / Estimated Vessel Length
Chart 10. Coefficient of Average Keel Cross-sectional Area to Estimated Vessel Length for Seagoing Vessels
Chart 11. Plot of Average Keel Cross-sectional Area to Estimated Vessel Length for Seagoing Vessels
Chart 12. Plot of Average Total Cross-sectional Area of Central Longitudinal Timbers to Estimated Vessel Length for Seagoing Vessels

[Includes Keel, Proto-keelson, and/or Central Stringers]
Chart 13. Coefficient of Combined Average Cross-Sectional Areas of the Keel and Central Longitudinal Timbers to Estimated Vessel Length in Mediterranean Seagoing Vessels

[Central timbers include proto-keelson or central stingers]
Chart 14. Coefficient of Average Keel Cross-sectional Area to Estimated Vessel Length for River Vessels

Keel Cross-sectional Area / Estimated Vessel Length

Vessels in Chronological Order
Chart 15. Plot of Average Keel Cross-sectional Area to Estimated Vessel Length for River Vessels.
Chart 16. Average Aspect Coefficient of Keels for River Vessels
(Molded Dimension/Sided Dimension)
Chart 17. Coefficient of Total Bottom Plank Cross-Sectional Area to Estimated Vessel Length for Northern European River Vessels

Vessels in Chronological Order

Zwammerdam 2  Zwammerdam 4  Zwammerdam 6  Drecht
Chart 18. Coefficient of Average Frame Cross-sectional Area to Estimated Vessel Length for Seagoing Vessels
Chart 19. Average Sided Dimensions of Frames in Seagoing Vessels
Chart 20. Coefficient of Average Frame Sided Dimension to Estimated Vessel Length of Mediterranean Seagoing Vessels
Chart 21. Average Center-to-Center Spacing of Frames in Mediterranean Seagoing Vessels
Chart 22. Coefficient of Average Center-to-Center Spacing of Frames to Estimated Vessel Length for Seagoing Vessels
Chart 23. Plot of Average Center-to-Center Spacing of Frames to Estimated Vessel Length for Seagoing Vessels
Chart 25. Coefficient of Average Open Space Between Frames to Estimated Vessel Length for Seagoing Vessels
Chart 26. Plot of Average Open Space between Frames to Estimated Vessel Length for Mediterranean Seagoing Vessels
Chart 27. Plot of Average Cross-Sectional Area of Frames to Average Open Space Between Frames for Seagoing Vessels.
Chart 28. Coefficient of Estimated Total Number of Frames to Estimated Vessel Length for Mediterranean Seagoing Vessels
Chart 29. Ratio of Estimated Total Number of Frames to Estimated Vessel Length for Seagoing Vessels
Chart 30. Average Sided Dimensions of Frames in River Vessels

Vessels Chronologically Ordered within Geographical Grouping
Chart 31. Plot of Average Frame Cross-sectional Area to Estimated Vessel Length for River Vessels

- Roman Vessels
- Germanic Vessels
- Rom.-Hri Vessels
- Log (Roman Vessels)
Chart 32. Plot of Average Frame Cross Sectional Area to Average Open Space Between Frames for River Vessels
Chart 33. Coefficient of Estimated Total Number of Frame Stations to Estimated Vessel Length for River Vessels
Chart 34. Average Planking Thicknesses of Mediterranean Seagoing Vessels
Chart 36. Plot of Average Planking Thickness to Estimated Vessel Length in Mediterranean Seagoing Vessels
Chart 37. Coefficient of Average Planking Thickness to Estimated Vessel Length for Mediterranean Seagoing Vessels
Chart 38. Average Planking Thicknesses (Side Timbers) in European River Vessels by Geographical Region of Deposition

Vessels in Chronological Order
Chart 39. Coefficient of Average Planking Thickness to Estimated Vessel Length for River Vessels
Chart 40. Plot of Average Planking Thickness to Estimated Vessel Length for River Vessels

- Oberstimm
- Zwammerdam/New Guy's
- Fiumicino
- Mainz
Chart 41. Coefficient of Average Planking Thickness to Estimated Vessel Length for Seagoing and River Vessels
Chart 42. Coefficient of Average Planking Thickness to Estimated Vessel Length for Seagoing and River Vessels
Chart 43. Average Planking Thicknesses of Vessels in Uncii
Chart 45. Differential of Average Plank Thickness to Late Antiquity Measurements of Uncii and Uncii-Drussus

Vessels in Chronological Order
Chart 46. Average Mortise and Tenon Sizes

Vessels in Chronological Order
Chart 47. Percentage of Unfilled Mortise Length

[Difference of average mortise length and average tenon width in relation to average mortise length]

Vessels in Chronological Order

Torre Sputa 190
Marseille - c 200
County Hall - c 250
Pompeii - c 250
Fiumicino 1 - c 350
Fiumicino 2 - c 350
Fiumicino 3 - c 350
Laurens 2 - c 350
Yassoki Ada - c 625
Drumont F - c 650
Yassoki Ada - c 650
Dor D - c 650
Chart 48. Average Center-to-Center Spacing of Mortise-and-Tenon Joints
## Chart 49. Propulsion and Wale Evidence for Mediterranean Sea-Going Merchantmen

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<th>c. 450-650</th>
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### Chart 50. Shape, Steering, and Structure Evidence for Mediterranean Sea-going Merchantmen

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Chart 51. Decoration Evidence for Mediterranean Sea-Going Merchantmen

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Chart 52. Propulsion Evidence for Mediterranean Sea-Going Warships

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Chart 53. Wale, Shape, Steering, and Structure Evidence for Mediterranean Sea-Going Warships

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Chart 54. Decoration Evidence for Mediterranean Sea-Going Warships

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</tr>
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<td>Goose</td>
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### Chart 55. Propulsion Evidence for River Warships

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<th>c. 450-650</th>
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<td>1</td>
<td>11</td>
</tr>
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<td>2 Banks</td>
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<td>11</td>
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## Chart 57. Decoration Evidence for River Warships

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<th>c. 450-650</th>
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<td>Forw. Proj. Flat</td>
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</tr>
<tr>
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<td>0.0%</td>
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<td>Inboard Proj. Bird</td>
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</tr>
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</tr>
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</tr>
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<td>10</td>
<td>0.0%</td>
</tr>
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## Chart 58. Propulsion, Wale, Shape, Steering, and Structure
### Evidence for Military River Transports, c. 50-250

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### Chart 59. Decoration Evidence for Military River Transports, c. 50-250

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### Chart 60. Propulsion, Wale, Shape, Steering, and Structure
### Evidence for Utility/Fishing Vessels, c. 225-450

<table>
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<th>Oars Banks</th>
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Chart 61. Decoration Evidence for Utility/Fishing Vessels, c. 225-450

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</tr>
<tr>
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<td>0.0%</td>
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<tr>
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Chart 62. Circumference and Area Values for Square and Rounded Hull Shapes

- **Square Circum.**
- **Rounded Circum.**
- **Square Area**
- **Rounded Area**

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<th>Circumference (m)</th>
<th>Area (sq. m)</th>
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<tr>
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*Note: The chart illustrates the relationship between beam and circumference/area for both square and rounded hull shapes.*
Chart 63. Primary and Secondary Methods of Fastening in Mediterranean Sea-Going Vessels

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<th>Secondary Nails</th>
<th>Primary Nails</th>
<th>Secondary Treenails</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bourse de Marseilles</td>
<td>c. 200</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Point de la Luque B</td>
<td>c. 315</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Laurons 2</td>
<td>c. 350</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yassi Ada</td>
<td>c. 350</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dramont F</td>
<td>c. 350</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pantano Longarini</td>
<td>c. 500</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Tantura A</td>
<td>c. 500</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Anse St. Gervais 2</td>
<td>c. 615</td>
<td></td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Yassi Ada</td>
<td>c. 625</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Dor D</td>
<td>c. 650</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Chart 64. Estimated Timber Dimensions for a 21-meter Vessel of Both Types

<table>
<thead>
<tr>
<th>Bourse de Marnesilles Type Dimensions</th>
<th>Yanni Ada Type Dimensions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Tbh./Side</strong></td>
<td><strong>Mtd.</strong></td>
</tr>
<tr>
<td>Planking</td>
<td>0.060</td>
</tr>
<tr>
<td>Decking</td>
<td>0.060</td>
</tr>
<tr>
<td>Posts</td>
<td>0.225</td>
</tr>
<tr>
<td>Keels</td>
<td>0.225</td>
</tr>
<tr>
<td>Frames</td>
<td>0.080</td>
</tr>
<tr>
<td>Keelson</td>
<td>0.230</td>
</tr>
<tr>
<td>Stringers</td>
<td>0.190</td>
</tr>
<tr>
<td>Attached Ceiling</td>
<td>0.080</td>
</tr>
<tr>
<td>Clamps</td>
<td></td>
</tr>
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</table>

Chart 65. Estimated Timber Volumes and Weights for Each Type Vessel

<table>
<thead>
<tr>
<th>Bourse de Marnesilles Type</th>
<th>Yanni Ada Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Planking - above water line</td>
<td>5.00</td>
</tr>
<tr>
<td>Planking - below water line</td>
<td>5.00</td>
</tr>
<tr>
<td>Decking</td>
<td>4.50</td>
</tr>
<tr>
<td>Posts/Keels - above water line</td>
<td>0.38</td>
</tr>
<tr>
<td>Posts/Keels - below water line</td>
<td>0.76</td>
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<tr>
<td>Frames</td>
<td>4.80</td>
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<tr>
<td>Keelson</td>
<td>0.28</td>
</tr>
<tr>
<td>Stringers</td>
<td>0.97</td>
</tr>
<tr>
<td>Attached Ceiling</td>
<td>1.47</td>
</tr>
<tr>
<td>Other Attached Ceiling</td>
<td></td>
</tr>
<tr>
<td>Clamps</td>
<td>2.00</td>
</tr>
<tr>
<td>Estimated Totals</td>
<td></td>
</tr>
<tr>
<td>Estimated Other Weight in Ship</td>
<td></td>
</tr>
<tr>
<td>Ext. Total Wt. of Ship w/o Cargo</td>
<td></td>
</tr>
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</table>

Chart 66. Estimated Cargo Capacities for Each Type Vessel

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
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<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>Bourse de Marnesilles Type</td>
<td>3rd</td>
<td>21</td>
<td>22.5</td>
<td>72.9</td>
<td>50.4</td>
<td>-2.2</td>
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<tr>
<td>Yanni Ada Type</td>
<td>7th</td>
<td>21</td>
<td>20.3</td>
<td>72.9</td>
<td>52.6</td>
<td>2.2</td>
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### Chart 67. Ships with Non-Amphora Primary Cargoes

<table>
<thead>
<tr>
<th>WRECK NAME</th>
<th>DATE</th>
<th>SITE LOCATION</th>
<th>CARGO</th>
<th>CARGO ORIGIN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ooze Deep</td>
<td>c. 65-105</td>
<td>Britannia</td>
<td>Mortaria</td>
<td></td>
</tr>
<tr>
<td>Fuenterrabia</td>
<td>c. 100-150</td>
<td>S. Hispaniae</td>
<td>Iron ore</td>
<td></td>
</tr>
<tr>
<td>Grand Bassin C</td>
<td>c. 120</td>
<td>S. Vienensis</td>
<td>Mortaria, lamps</td>
<td></td>
</tr>
<tr>
<td>Porto Fisso</td>
<td>c. 117-138</td>
<td>Italia</td>
<td>Lead ingots</td>
<td></td>
</tr>
<tr>
<td>St. Gervais A</td>
<td>c. 140</td>
<td>S. Vienensis</td>
<td>Lead ingots, iron bars</td>
<td></td>
</tr>
<tr>
<td>Pakloni</td>
<td>2nd</td>
<td>Pannoniae</td>
<td>Courseware</td>
<td></td>
</tr>
<tr>
<td>Pracitus</td>
<td>2nd</td>
<td>Moesiae</td>
<td>Sculpture</td>
<td></td>
</tr>
<tr>
<td>Viganj</td>
<td>2nd</td>
<td>Pannoniae</td>
<td>Pottery from Aegean</td>
<td>Asiana-Moesiae</td>
</tr>
<tr>
<td>Les St. Maries-de-la-Mer C</td>
<td>2nd</td>
<td>S. Vienensis</td>
<td>Copper ingots</td>
<td></td>
</tr>
<tr>
<td>Bordeaux</td>
<td>c. 161</td>
<td>S. Vienensis</td>
<td>Terra Sigillata (Vienneñs and Hispaniae), 4,000+ Br coins</td>
<td>S. Vienensis, S. Hispaniae</td>
</tr>
<tr>
<td>Hof/Hacarmel A</td>
<td>c. 160-170</td>
<td>Orientes</td>
<td>Bronze statuery</td>
<td></td>
</tr>
<tr>
<td>Methone C</td>
<td>2nd-3rd</td>
<td>Moesiae</td>
<td>Stone sarcophagi</td>
<td></td>
</tr>
<tr>
<td>Pudding-Pan Rock</td>
<td>c. 175-200</td>
<td>Britannia</td>
<td>Terra sigillata (Lezoux), tiles</td>
<td>NE Galliae</td>
</tr>
<tr>
<td>Plemmiro B</td>
<td>c. 200</td>
<td>Italia</td>
<td>Iron bars</td>
<td></td>
</tr>
<tr>
<td>Mellieha</td>
<td>c. 200-250</td>
<td>Italia</td>
<td>Mortaria, Glass vessels</td>
<td></td>
</tr>
<tr>
<td>San Pietro</td>
<td>c. 200-250</td>
<td>Italia</td>
<td>Marble sarcophagi</td>
<td></td>
</tr>
<tr>
<td>Putina Crapazza</td>
<td>3rd</td>
<td>Italia</td>
<td>Tin ingots</td>
<td></td>
</tr>
<tr>
<td>Saporta C</td>
<td>3rd</td>
<td>Moesia</td>
<td>Assos Grande sarcophagi</td>
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</tr>
<tr>
<td>Ayia Galini</td>
<td>c. 270-290</td>
<td>Moesiae</td>
<td>Bronze and other metal scrap</td>
<td></td>
</tr>
<tr>
<td>Wantzeratu</td>
<td>Lt. 3rd</td>
<td>S. Vienensis</td>
<td>Mill stones</td>
<td></td>
</tr>
<tr>
<td>Ploumanach</td>
<td>3rd-4th</td>
<td>S. Vienensis</td>
<td>Lead ingots</td>
<td></td>
</tr>
<tr>
<td>Ras el Basst</td>
<td>Mid. 3rd-4th</td>
<td>S. Hispaniae</td>
<td>Mortaria</td>
<td></td>
</tr>
<tr>
<td>Plemmiro A</td>
<td>4th-5th</td>
<td>Italia</td>
<td>Metal objects and scrap</td>
<td></td>
</tr>
<tr>
<td>Taranto A</td>
<td>c. 400-650</td>
<td>Italia</td>
<td>Mill stones</td>
<td></td>
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<tr>
<td>Favoritze</td>
<td>c. 450-600</td>
<td>S. Hispaniae</td>
<td>Bronze scrap and ingots</td>
<td></td>
</tr>
<tr>
<td>St. Gervas B</td>
<td>c. 600-625</td>
<td>S. Vienensis</td>
<td>Wheat, pitch</td>
<td></td>
</tr>
<tr>
<td>Grazel B</td>
<td>c. 631</td>
<td>S. Vienensis</td>
<td>Coins from Constantinople, balance pan/wts., stockyard, Br objects</td>
<td></td>
</tr>
<tr>
<td>Palizi Marini</td>
<td>Roman</td>
<td>Italia</td>
<td>Sulphur ingots</td>
<td></td>
</tr>
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## Chart 69. Use of the Roman and Byzantine Foot in Architectural Projects

<table>
<thead>
<tr>
<th>BUILDING</th>
<th>DATE</th>
<th>LOCATION</th>
<th>ELEMENT</th>
<th>ROMAN FEET</th>
<th>BYZANTINE FEET</th>
</tr>
</thead>
<tbody>
<tr>
<td>S. Clemente</td>
<td>c. 380</td>
<td>Rome, Italia</td>
<td>Overall</td>
<td>50 x 120 x 45</td>
<td></td>
</tr>
<tr>
<td>Ch. of S. Ambrose</td>
<td>c. 385</td>
<td>Milan, Italia</td>
<td>Overall</td>
<td>300 x 100</td>
<td></td>
</tr>
<tr>
<td>Basilica at Domous el Karita</td>
<td>4th</td>
<td>N. Africa</td>
<td>Basilica length</td>
<td>215</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Complex length</td>
<td>490</td>
<td></td>
</tr>
<tr>
<td>Ch. of S. Sabina</td>
<td>422-432</td>
<td>Rome, Italia</td>
<td>Window width</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Window height</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Window spacing</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>San Simpliciano Church</td>
<td>5th</td>
<td>Italia</td>
<td>Nave length</td>
<td>200</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Nave width</td>
<td>75</td>
<td></td>
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<td>Wall height</td>
<td>60</td>
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<td></td>
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<td>Window height</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td>S. Paolo fuori le mura</td>
<td>382-400</td>
<td>Rome, Italia</td>
<td>Nave width</td>
<td>80</td>
<td></td>
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<tr>
<td>St. Peter’s (original)</td>
<td>Beg. c. 321</td>
<td>Rome, Italia</td>
<td>Column spacing</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>St. Mary’s Church</td>
<td>c. 400</td>
<td>Ephesus, Asiaña</td>
<td>Total length</td>
<td>275</td>
<td></td>
</tr>
<tr>
<td>Myrelnion Church</td>
<td>5th</td>
<td>Constantinople, Thracia</td>
<td>Interior diameter</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>Martyrium of St. Philip</td>
<td>5th</td>
<td>Hierapolis</td>
<td>Central room width</td>
<td>70</td>
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<td></td>
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<td>Enclosing building</td>
<td>197 x 203</td>
<td></td>
</tr>
<tr>
<td>Church of H. Leonidus and Lechaion</td>
<td>5th</td>
<td>Asiaña</td>
<td>Total length</td>
<td>600</td>
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<td></td>
<td></td>
<td></td>
<td>Atrium + Narthex</td>
<td>187</td>
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<td>Ch. of Hagia Sophin</td>
<td>532-7</td>
<td>Constantinople, Thracia</td>
<td>Overall</td>
<td>225 x 240</td>
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<td>Square b/w piers</td>
<td>100</td>
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<tr>
<td>Ch. Of the Nativity</td>
<td>6th</td>
<td>Bethlehem, Orients</td>
<td>Forecourt</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Atrium</td>
<td>148 x 92</td>
<td></td>
</tr>
<tr>
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<td></td>
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<td>Nave and 4 aisles</td>
<td>93 x 95</td>
<td></td>
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<tr>
<td>Amphora Type</td>
<td>Date Range (cent.)</td>
<td>Production Origin</td>
<td>Cargo</td>
<td>Amphora Material Vol (cc)</td>
<td>Capacity (cc)</td>
</tr>
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<td>-------------</td>
<td>--------------------</td>
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<td>-------</td>
<td>--------------------------</td>
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</tr>
<tr>
<td>Dressel 43</td>
<td>2</td>
<td>Crete</td>
<td>Wine</td>
<td>3961</td>
<td>18197</td>
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<td>Greek</td>
<td>2</td>
<td>Aegean</td>
<td>Wine</td>
<td>7179</td>
<td>26724</td>
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<td>Dr 38</td>
<td>2</td>
<td>S. Spain</td>
<td>Fish Sauce</td>
<td>7495</td>
<td>19540</td>
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<tr>
<td>Beltran IIIB</td>
<td>2</td>
<td>S. Spain</td>
<td>Fish Sauce</td>
<td>9879</td>
<td>31794</td>
</tr>
<tr>
<td>Dr 1-1a</td>
<td>2</td>
<td>S. Spain</td>
<td>Fish Sauce</td>
<td>7717</td>
<td>14425</td>
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<tr>
<td>Gaulois 5</td>
<td>2</td>
<td>S. Gaul</td>
<td>Wine</td>
<td>2585</td>
<td>9737</td>
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<tr>
<td>Dressel 28</td>
<td>2</td>
<td>SW Spain</td>
<td>Wine</td>
<td>6571</td>
<td>23285</td>
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<td>Apessa M54</td>
<td>2</td>
<td>S. Turkey</td>
<td>Wine</td>
<td>6552</td>
<td>32908</td>
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<tr>
<td>Penoppii VIII</td>
<td>2-3</td>
<td>Crete</td>
<td>Wine</td>
<td>7670</td>
<td>37376</td>
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<tr>
<td>Richborough S27</td>
<td>2-3</td>
<td>SW Italy</td>
<td>Wine</td>
<td>3169</td>
<td>9947</td>
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<td>Apessa G197</td>
<td>2-3</td>
<td>Crete</td>
<td>Wine</td>
<td>4317</td>
<td>22624</td>
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<td>Ido-20</td>
<td>3-3</td>
<td>S. Spain</td>
<td>Olive Oil</td>
<td>12305</td>
<td>86679</td>
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<td>3-3</td>
<td>NE Italy</td>
<td>Wine</td>
<td>7231</td>
<td>24500</td>
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<td>Gaulois 4</td>
<td>2-3</td>
<td>S. Gaul</td>
<td>Wine</td>
<td>3267</td>
<td>19091</td>
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<tr>
<td>Roman Egypt</td>
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<td>Egypt</td>
<td>Wine</td>
<td>12268</td>
<td>30878</td>
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<td>N. Africa</td>
<td>Olive Oil</td>
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<td>N. Africa</td>
<td>Wine</td>
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<td>13655</td>
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<td>Aegean</td>
<td>Wine</td>
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<td>8139</td>
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<td>Dr 23</td>
<td>2-5</td>
<td>S. Spain</td>
<td>Olive Oil</td>
<td>7216</td>
<td>21789</td>
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<td>Apf 1</td>
<td>2-5</td>
<td>N. Africa</td>
<td>Olive Oil</td>
<td>7447</td>
<td>37841</td>
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<tr>
<td>Dressel 30</td>
<td>2-4</td>
<td>N. Africa</td>
<td>Wine</td>
<td>5314</td>
<td>20933</td>
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<tr>
<td>Almagro 50</td>
<td>3-4</td>
<td>W. Spain</td>
<td>Fish Sauce</td>
<td>5665</td>
<td>20877</td>
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<td>Almagro 51 A-B</td>
<td>3-4</td>
<td>W. Spain</td>
<td>Fish Sauce</td>
<td>4952</td>
<td>22509</td>
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<tr>
<td>Almagro 51 C</td>
<td>3-4</td>
<td>W. Spain</td>
<td>Fish Sauce</td>
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<td>21958</td>
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<td>Aegean</td>
<td>Wine</td>
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<td>9737</td>
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<td>Belt 72</td>
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<td>W. Spain</td>
<td>Fish Sauce</td>
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<td>10339</td>
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<td>Apf 11</td>
<td>3-5</td>
<td>N. Africa</td>
<td>Fish Sauce</td>
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<td>54006</td>
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<td>Apf Cy - med</td>
<td>3-5</td>
<td>N. Africa</td>
<td>Fish Sauce</td>
<td>6906</td>
<td>15991</td>
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<td>LR4</td>
<td>4-6</td>
<td>Egypt/Caria</td>
<td>Wine?</td>
<td>3282</td>
<td>14765</td>
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<tr>
<td>Koina LII</td>
<td>4-6</td>
<td>E. Med/ Elba</td>
<td>Wine?</td>
<td>2208</td>
<td>6564</td>
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<td>LR3</td>
<td>4-6</td>
<td>N-S Turkey/E. Greece</td>
<td>?</td>
<td>2003</td>
<td>11717</td>
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<tr>
<td>Apf Cy I lg</td>
<td>4-7</td>
<td>N. Africa</td>
<td>Fish Sauce</td>
<td>8828</td>
<td>80678</td>
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<td>LR7</td>
<td>4-7</td>
<td>Egypt</td>
<td>Wine?</td>
<td>1475</td>
<td>3324</td>
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<tr>
<td>LR1a</td>
<td>5-7</td>
<td>S. Turkey</td>
<td>Wine</td>
<td>5114</td>
<td>23611</td>
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<tr>
<td>Spainia</td>
<td>5-7</td>
<td>N. Africa</td>
<td>Wine</td>
<td>2599</td>
<td>3463</td>
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<td>Late Roman 1b</td>
<td>5-7</td>
<td>N. Africa</td>
<td>Wine</td>
<td>3667</td>
<td>23639</td>
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<tr>
<td>LR56</td>
<td>5-7</td>
<td>Egypt/ Palestine</td>
<td>Wine</td>
<td>2665</td>
<td>19402</td>
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<tr>
<td>LR2</td>
<td>5-7</td>
<td>N-S Turkey/E. Greece</td>
<td>Wine</td>
<td>6021</td>
<td>37516</td>
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<td>Koina LXIII</td>
<td>6-7</td>
<td>N. Africa</td>
<td>Fish Sauce</td>
<td>9805</td>
<td>69473</td>
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</table>
Chart 71. Average Amphora Efficiency: 2nd - 7th Century AD
(All Amphora Types)

All Amphorae
Most Commonly Shipped Amphorae

Efficiency Coefficient (Capacity Volume/Material Volume)

Century
2nd 3rd 4th 5th 6th 7th
Chart 72. Average Wine Amphora Efficiency: 2nd - 7th Century AD
Chart 74. Changes in Shipbuilding Methods

- Very large ships rare
- Accelerated decrease in planking thickness
- Sharp decrease in tenon dimensions
- Minimum tenon size reached
- Minimum marlinspike size reached
- Increase in keel cross-section area, aspect coefficients
- Relative frame size equilibrium
- c. 25% of frames attached to keel
- Increased number of frames
- Unpegged mortise-and-tenon joints
- Predominant use of iron nails for frame-plank attachment
- Rounded hull midship cross-sections
- More 'boxy' hull midship cross-sections

2nd 3rd 4th 5th 6th 7th
Chart 75. Changes in Shipbuilding Methods in Relation to Socio-Political Events

<table>
<thead>
<tr>
<th>Roman push into Britain</th>
<th>Econ.-Bureaucratic Restructuring/ Border Wars/ Civil Wars</th>
<th>Germanic-Scythian Invasions</th>
<th>Estab.-Rule of Western Kingdoms/ Further Invasions</th>
<th>Exp. of Rmn Emp</th>
<th>Exp. of Arab Caliphate into Med</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>Very large ships rare</td>
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<td></td>
<td>Accelerated decrease in planking thickness</td>
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<td>Sharp decrease in tenon dimensions</td>
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<td>Minimum tenon size reached</td>
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<td>Increase in hull cross-section area, aspect coefficients</td>
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<td></td>
<td>Relative frame size equilibrium</td>
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<td>25% of frames attached to deck</td>
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<tr>
<td></td>
<td>Increased number of frames</td>
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<tr>
<td></td>
<td>Unpinned mortise end-tapee joints</td>
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<tr>
<td></td>
<td>Predominant use of iron nails for frames-plank attachment</td>
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<tr>
<td></td>
<td>More 'boxy' hull midship cross-sections</td>
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</table>

2nd  3rd  4th  5th  6th  7th
APPENDIX B
ICONOGRAPHIC EXAMPLES

Fig. 1. Utility vessel. Source: Blanchard-Lemee, et al. Mosaics of Roman Africa, fig. IX-a.

Fig. 2. Utility vessel. Source: Blanchard-Lemee, et al. Mosaics of Roman Africa, fig. X-b.
Fig. 3. Merchant vessel. Source: Casson, *Ships and Seamanship*, fig. 150.

Fig. 4. Merchant vessel. Source: Casson, *Ships and Seamanship*, fig. 151.
Fig. 5. Merchant vessel. Source: Casson, Ships and Seamanship, fig. 154.

Fig. 6. Merchant vessel. Source: Casson, Ships and Seamanship, fig. 155.
Fig. 7. Merchant vessel. Source: Casson, *Ships and Seamanship*, fig. 156.

Fig. 8. Merchant vessel. Source: Casson, *Ships and Seamanship*, fig. 175.
Fig. 9. Merchant vessel. Source: Casson, *Ships and Seamanship*, fig. 146.

1. Lifts
2. Brails
3. Halyard
4. Brace
5. Shrouds
6. Sheet
7. Stern structure
8. Goose head
9. Deck projection?
10. Quarter rudder
11. Throughbeams
12. Sheerwale
13. Wales
14. Quarter rudder assembly
Stern shape: Convex
Square rig

Fig. 10. Merchant vessel. Source: Casson, *Ships and Seamanship*, fig. 149.

1. Mast
2. Lifts
3. Brails
4. Halyard
5. *Artemon*
6. Banner
7. Sheet
8. Flat bow terminus
9. Stern structure?
10. Flat stern terminus
11. Goose head
12. Throughbeams
13. Quarter rudder assembly
Stern shape: Convex
Box shape: Convex
Square rig
Fig. 11. Merchant vessel. Source: Casson, *Ships and Seamanship*, fig. 145.

1. Mast  
2. Lifs  
3. Banner  
4. *Artemon*  
5. Stem Sail  
6. Goose head  
7. Deck projection  
8. Quarter rudders  
9. Brails  
10. Backstay  
11. Forestay  
12. Shoud  
13. Sheet  
14. Volute  
15. Wales  
16. Crenellation  
17. Quarter rudder assembly  
18. Midship structure  
19. Bird decoration?  
20. Flat stern terminus  
21. Oculus

**Vessel to Left**: Stern shape: Convex, Bow shape: Concave, Square rigs  
**Vessel to Right**: Stern shape: Convex, Bow shape: Concave, Square rigs

Fig. 12. Merchant vessel. Source: Casson, *Ships and Seamanship*, fig. 140.

1. Mast  
2. Shrouds  
3. Backstay  
4. Forestay  
5. Ladder  
6. *Artemon*  
7. Flat bow terminus  
8. *Aphlaston*  
9. Stern structure  
10. Quarter rudder assembly  
11. Quarter rudder  
12. Oars  

Stern shape: Convex  
Bow shape: Concave  
Square rig?
Fig. 13. Merchant vessel. Source: Casson, *Ships and Seamanship*, fig. 147.

Fig. 14. Merchant vessel. Source: Casson, *Ships and Seamanship*, fig. 141.
Fig. 15. Merchant vessel. Source: Casson, *Ships and Seamanship*, fig. 181.

Fig. 16. Merchant vessels. Source: Casson, *Ships and Seamanship*, fig. 148.

1. Mast  
2. Lateen Rig  
3. Quarter rudder assembly  
4. Goose head  
5. Quarter rudder  
6. Forward projection  
7. Sheet  
8. Wale  
Bow shape: Convex  
Stern shape: Convex  
Lateen rig

1. Mast  
2. Lifts  
3. Forestay  
4. Shrouds  
5. Backstay  
6. Flat bow terminus  
7. Flat stern terminus  
8. Sheerwale  
9. Brails  
10. Quarter rudder  
11. Quarter rudder assembly  
12. Wales  
13. Brace  
14. Bird head  
15. Zoomorphic head?

Both vessels: Bow shape: Convex, Stern shapes: Convex, Square rigs
Fig. 17. Merchant vessel. Source: Casson, *Ships and Seamanship*, fig. 142.

1. Mast
2. *Artemon*
3. Brails
4. Shrouds
5. Brace
6. Stern structure
7. Flat stern terminus
8. Quarter rudder assembly?
9. Quarter rudder
10. Flat bow terminus
11. Sheet
Stern shape: Convex
Bow shape: Convex
Square rig

Fig. 18. Merchant vessel. Source: Casson, *Ships and Seamanship*, fig. 143.

1. Mast
2. Lifts
3. Brails
4. Brace
5. Backstay
6. Sheet
7. Stern structure
8. Quarter rudder assembly
9. Quarter rudder
10. Flat bow terminus
11. Flat stern terminus
12. Shrouds
Bow shape: Convex
Stern Shape: Convex
Square rig
13. Wales
Fig. 19. Warship. Source: Foucher, "Navires et barques figures", fig. T-1.

1. Masts  
2. Lifts  
3. Brails  
4. Sheet  
5. Forward projecting Volute  
6. Shrouds  
7. Mast crutches  
8. Railing/screen  
9. Stern structure  
10. Aplaston  
11. Wales/outboard-gangway  
12. Quarter rudders  
13. Oars  
14. Ram  
15. Oculus  
16. Quarter rudder assembl.  
17. Artemon

Bow shape: Concave, Stern shape: Convex, Square rig

Fig. 20. Warship. Source: Foucher, "Navires et barques figures", fig. A-4.

1. Aplaston  
2. Deck projection?  
3. Quarter rudders  
4. Forward projecting volute  
5. Throughbeams  
6. Ram  
7. Oars  
8. Quarter rudder assembly  
Stern shape: Convex  
Bow shape: Concave
Fig. 21. Warship. Source: Foucher, "Navires et barques figures", fig. S-1.

1. Lifts  
2. Banner  
3. Artemon  
4. Backstay  
9. Standards  
10. Inward projection  
11. Stern structure  
12. Quarter rudder  
13. Oculus  
14. Ram  
15. Wales  
16. Sheerwale  
17. Upward projecting volute  
18. Structure?  
19. Oars  
20. Shrouds

Stern shape: Convex. Bow shape: Concave, Square rig


1. Aphlaston elements  
2. Bird?  
3. Artemon  
4. Stern structure  
5. Wale/outboard-gangway  
6. Quarter rudder  
7. Ram  
8. Oars  
9. Goose head  
10. Screen

Fig. 22: Stern shape: Convex. Bow shape: Concave, Square rig
Fig. 23: Stern shape: Convex. Bow shape: Flat, Square rig
Fig. 24. Warship. Herbert, *Roman Imperial Coins*, fig. XXXVI-943.

Fig. 25. Warship. Herbert, *Roman Imperial Coins*, fig. XXXIII-850.

Figs. 26. and 27. Warships. Robertson, *Roman Imperial Coins*, figs. 68-53 and 7-6AV.


Figs. 24 and 25: Stern shape: Convex, Bow shape: Concave, Square rig
Figs. 26 and 27: Stern shape: Convex, Bow shape: Flat
Fig. 28. Warship. Source: Ellmers, "Shipping on the Rhine during the Roman period," fig. 12.

2. Screen           5. Quarter rudder    8. Sheerwale

Bow shape: Concave, Stern shape: Convex
APPENDIX C
FIGURES USED IN ANALYSES

Merchantmen

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Myers, B. S. (ed.), 1985 The History of Art (New York) p. 197, fig. 10

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Military Vessels

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Other Vessels


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APPENDIX E

TIMELINE

97-117  Rule of Emperor Trajan
100  Estimated date for deposition of the Bevaix, Oberstimm 1 and 2 vessels
117-138  Rule of Emperor Hadrian
120  Estimated date for deposition of the Grand Bassin C vessel
130  Estimated date for deposition of the Kapel Avazaath and Kapel Avasoath vessels
138-161  Rule of Emperor Antoninus Pius
140-160  Estimated date for deposition of the De Meern 1 and 2, Woerden 1, New Guys House
Boat, Zwammerdam 1-6, Capo Taormina, St. Tropez A, and Pointe de la Luque A
vessels
161-180  Rule of Emperor Marcus Aurelius
161-169  Rule of Emperor Lucius Verus
175-200  Estimated date for deposition of the Camarina vessel
180  Estimated date for deposition of the Bruges vessel
180-192  Rule of Emperor Commodus, foundation of the classis Africana in Carthage
193  Rule of Emperors Pertinax and Didius Julianus
193-211  Rule of Emperor Septimius Severus
200  Severus campaigning along Danube, estimated date for deposition of the Woerden 3.
Druten, Torre Sgarrata, Punta Scifo, Bourse de Marseilles, and Blackfriars vessels
204  Severus moves forces to North Africa for campaign
205  Restoration of Hadrian’s wall begins
208  Severus departs with forces for Britain due to rebellion in north
209  Severus campaigns in Scotland
211-212  Rule of Emperor Geta
211-217  Rule of Emperor Caracalla
213  Roman forces defeat Alamanni incursion
215  Antoninianus, silver coin, first issued; estimated date for deposition of the Giglio Porto
vessel
217-218  Rule of Emperor Macrinus
218-222  Rule of Emperor Elagabalus
222-235  Rule of Emperor Alexander Severus
225  Estimated date for deposition of the San Pietro, Salakta, Marzamemi A.
Methone C, and Pointe Debie B vessels
230  Persians invade Mesopotamia, lay siege to Nisibis
232  Persian forces defeat Romans in large battle
234  Romans defeat incursion of Alamanni
235  Romans defeat incursion of Alamanni
235-238  Rule of Emperor Maximinus
236  Goths attack the city of Histria
236-237  Dacians and Sarmations defeated by Roman forces
238  Rule of Emperors Gordian I (N. Africa), Gordian II (N. Africa), Balbinus (Italy), and
Pupienus (Italy)
238-244  Rule of Emperor Gordian III
241  Goths attack the city of Marcianople
242  Roman forces begin major attack on Persian forces
244  Roman Empire and Persian Empire agree to peace accord
244-249  Rule of Emperor Philip
245-247  Roman forces campaign on Danube versus Germanic groups
249-251  Rule of Emperor Decius
Estimated date for deposition of the Monaco, County Hall, Pommegues, Punta Ala, Giardini, Torre Chianca, Caesarea C, and Capo Granitola A vessels

Rule of Emperor Trebonianus Gallus

Goths attack across Danube; Persians attack Roman forces in Mesopotamia

Rule of Emperor Aemilianus

Rule of Emperor Valerian

Rule of Emperor Gallienus

Marcomanni attack Roman forces in Pannonia, raid Ravenna

Goths set out across Black Sea, attack city of Pityus and Trapezus

Franks attack across lower Rhine River

Goths attack the city of Nicomedia; Roman forces invade Persia

Goths and Carpi attack Roman forces along Danube

Roman forces move deep into Persian territory, Emperor Valerian captured

Postumus forms Gallic Empire; rule continued by Victorinus and Tetricus

Edaenathus forms Palmyrene Empire; rule continued by Zenobia and Vabalath; Franks establish pirate base in North Africa

Plague reaches Italy and North Africa

Citizenship granted to all eligible males in Roman Empire

Goths and Heruli invade Asia Minor

Goths attack the city of Tomi, invade Greece

Goths attack the west coast of Asia Minor, east coast of Greece, and Cyprus

Rule of Emperor Claudius

Roman forces defeat marauding Goths

Aurelian walls began in Rome

Rule of Emperor Quintillus; Goths attack the city of Nassas; Franks and Alamanni begin attacks on Imperial territory in Gaul; Dacia abandoned by Roman forces

Rule of Emperor Aurelian

Roman forces crush last of Palmyrene breakaway state and revolt in Egypt

Aurelian defeats Tetricus and reabsorbs Gallic Empire

Saxon raids on southeastern Britain and northern Gaul intensify; Romans begin construction of Saxon shore forts; estimated date for deposition of the Guernsey vessel

Rule of Emperor Tacitus

Rule of Emperor Probus

Roman deliver severe defeat to Germanic and Gothic groups

Roman forces attack Vandals along Danube

Emperor Probus settles war captives in Asia Minor

Probus suppresses Bonosus

Rule of Emperor Carus

Rule of Emperors Carinus and Numerian

Mesopotamia ceded by Persians

Rule of Emperor Diocletian in the East

Carausius establishes breakaway empire in northern Gaul and Britain; Imperial forces defeat Baqualdae

Roman forces deliver heavy defeat to Frankish pirates

Rule of Emperor Maximian in the West

Roman Empire and Frankish Kingdom strike peace accord

Roman forces battle Sarmatians; first mention of Franks by Roman writers

Roman forces battle Sarmatians, suppress revolt in Egypt

Constantius reclaims Britain and northern Gaul for Roman Empire, begins repairs to Hadrian’s wall and forts; Roman forces defeat Persians in Mesopotamia; Egyptian revolt under Domitianus

Franks begin attacks on Saxon shore fortifications; Roman forces crush Egyptian revolt, others attack Persia; Frankish raids on Italian and African coasts
297-298
Alamanni attack and are repelled by Roman forces

298
Roman forces defeat large force of Moors in North Africa

299
Roman forces defeat Saracens in Syria

300
Estimated date for deposition of the Capo Granitola D. Laurons 1, and Isola della
Corenti, and Fiumicino 1-4 vessels

301
Diocletian delivers price edicts

305-306
Rule of Emperor Constantius in the West

305-313
Rule of Emperor Maximinus in the East

306-307
Rule of Emperor Severus II in the West, invades Italy, eventually defeated

306-312
Rule of Emperor Maxentius (Italy)

307-337
Rule of Emperor Constantine: 307-312 in West, 312-337 entire Empire, reconstruction
of Britain

308-324
Rule of Emperor Licinius: 308-312 in East, 312-324 entire Empire

311
Alexander rebels against Maxentius in Carthage

312
Battle of Milvan Bridge, Constantine victorious

313-315
Construction of the arch of Constantine

315
Estimated date for deposition of the Pointe de la Luque B vessel

321
Construction begins on church of S. Petre in Rome

322
Roman forces drive Sarmatians from Pannonia

323
Roman forces drive Goths from Thrace

330
Constantine moves imperial residence to Constantinople; construction begins on the
basilica near site of Calvary n Jerusalem

337-340
Rule of Emperor Constantine II in the West

337-361
Rule of Emperor Constantius II: 337-355 in East, 355-360 entire Empire

340-350
Rule of Emperor Constans in the West

343
Earliest firm date for establishment of office of ‘Count of the Saxon Shore’

350
Tervingi and Taifali attack across Danube River; Alans move west from Caspian Sea
region; Magnentius draws troops out of Britain for coup attempt; estimated date for
deposition of the Yverdon 2, Laurons 2, Nydam, Laurons 3 and 4, Yassi Ada, and
Dramont F vessels; approximate date for construction of the basilica at Domous el
Karita in North Africa and church of S. Costanza in Rome

350-353
Rule of Emperor Magnentius

357
Roman forces defeat Alamanni near Argentorate, extend campaign to Franks (to 358)

359
War resumed between Roman and Persian Empires

360-363
Rule of Emperor Julian: 360-361 in West, 361-363 entire Empire

363
Peace struck between Roman and Persian Empires

363-364
Rule of Emperor Jovian

364
Emperor censures privileges of shippers of logs for baths

364-375
Rule of Emperor Valentinian in the West

364-378
Rule of Emperor Valens in the East

365
Procopius rebels against Emperor Valens, defeated in 366

365-381
Rule of Visigoths by Athanaric

367
Picts, Scots, and Saxons simultaneously attack Roman forces in Britain

369
Roman forces in Britain restore order, restore Hadrian’s wall, establish signal stations on
Yorkshire coast area

375
Alans and Gruuthungi Goths move west across Dnestr River

375-383
Rule of Emperor Gratian in the West

375-392
Rule of Emperor Valentinian II in Italy and Illyricum

375-400
Estimated date for deposition of the Skerki Bank and Mainz River vessels

376
Huns drive some Gothic groups across Danube; Roman forces engage Gothic groups at
Marcianople

377
Gothic and Roman forces clash at Ad Salices and Dibiatum

378
Roman forces defeated by amalgam of Goths near Adrianople, Emperor Valens killed,
battles continue at Sardica, Succi Pass, and Constantinople

379-395  Rule of Emperor Theodosius in the East
380  Construction begins on the church of S. Clemente in Rome; construction completed on
curch of the Hole Sepulchre in Jerusalem
382  Goths forge treaty with Roman Empire
382-400  Construction of church of S. Paolo fuori le mura in Rome
383  Maximus draws legion XX Valaria Victrix out of Britain in bid for emperor
383-388  Rule of Emperor Maximus in the West
385  Construction begins on the church of S. Ambrose in Milan
391  Imperial edicts against paganism
392-394  Rule of Emperor Eugenius in the West
395  Huns move west over Dnepr River, and into Armenia-Cappadocia; Roman Empire split
into East and West administrations; Visigoths ravage Greece
395-410  Rule of Goths by King Aleric
395-423  Rule of Emperor Honorius in the West
395-408  Stilicho as regent in the West
395-408  Rule of Emperor Arcadius in the East
396  Stilicho defeats Visigothic forces in Greece
396-398  Stilicho campaigns against seaborne raids by Picts, Scots, and Saxons
400  Hadrian's wall abandoned; estimated date for beginning of construction of church of S.
Maria in Ephesus; estimated date for deposition of the Kerme Gulf and Port-Vendres 1
vessels
401  Roman troops willing to depart are withdrawn from Britain to Italy
402  Vandals, Alans, and Sueves move into Western Imperial territories; Ravenna established
as capital of Western Empire
406  Rhine river freezes, Vandals, Suevi, and Burgundians among groups to cross
407  Constantine III removes much of remaining Roman forces from Britain for attempt at
attaining emperor
407-413  Constantine III sets up regime in northern Gaul, succeeded by Jovinus and Sebastianus
408  Saxon invasions on Britain begin; Alaric leads Visigoths into Italy
408-450  Rule of Emperor Theodosius II in the East
409  Vandals, Suevi, and Alans make their way to Hispania
410  Britain formally left to its own defenses by Roman Empire; Rome sacked by Visigoths
410-415  Rule of Visigoths by King Athaulf
412  Alamanni attack city of Worms
414  Visigoths invade Gaul, settle in southwest region centered on Narbonne
415  Naval blockage by Romans forces Visigoths from southwest Gaul - make their way into
Hispania; estimated date for deposition of the Dromont E vessel
418-451  Rule of Visigoths by King Theoderic
421  Rule of Emperor Constantius III in the West
422-432  Construction of church of S. Sabina in Rome
423-425  Rule of Emperor Johannes in the West
424  Construction begins on the mausoleum of Galla Placidia in Ravenna
425  Siege of Arelate in southern Gaul by Visigoths is unsuccessful
425-455  Rule of Emperor Valentinian III in the West
428-477  Rule of Vandals by King Geiseric
429  Vandals cross from Hispania to North Africa
430  Hippo Regius in North Africa besieged by Vandals
435  Eastern Mauretania and Numidia ceded to Vandals by Empire
436  Roman and Hun forces under Aetius defeat Burgundians
437  Huns attack and burn Trier; Roman forces under Aetius defeat Bagaudae in Armorica
439  Carthage taken by Vandals, set up kingdom
443  Empire settles Burgundians in southeastern Gaul
Roman forces under Aetius defeat Franks and drive them east across Rhine
Council of Ephesus
Estimated beginning construction date for Myrelaion church in Constantinople and the martyrdom of S. Philip in Hierapolis
Rule of Emperor Marcian in the East
Roman forces under Aetius defeat Huns at Catalaunian fields in Gaul; Council of Chalcedon
Ostrogoths settle in Panonnia
Rule of Emperor Petronius Maximus in the West; Rome sacked by Vandals
Rule of Emperor Avitus in the West
Rule of Emperor Majorian in the West
Rule of Emperor Leo in the East
Franks take city of Cologne
Rule of Emperor Libius Severus in the West
Visigoths take Barcino in southern Hispania, secure Mediterranean port
Roman and Frankish forces defeat Visigoths in northern Gaul
Rule of Visigoths by Euric
Rule of Emperor Anthemius in the West
Failed overseas attack on Vandal kingdom by Empire
Visigoths expand into Auvergne
Construction begins on church of S. Martin in Tours
Rule of Emperor Olybrius in the West; Ricimer captures Rome
Rule of Emperor Glycerius in the West
Rule of Emperor Nepos in the West
Rule of Emperor Zeno in the East
Visigothic kingdom declared independent; Franks expand into Belgica
Rule of Emperor Basiliscus in the East
Rule of Emperor Romulus Augustulus in the West
Western portion of Empire effectively lost
Odoacer rules Italy
Rule of Vandals by King Huneric
Rule of Franks by King Clovis
Rule of Vandals by King Gunthar mund
Rule of Visigoths by Euric
Franks defeat forces of Syagrius at Soissons
Rule of Ostrogoths by King Theodoric
Rule of Emperor Anastasius
Construction of S. Apollinare Nuovo in Ravenna
Franks besiege Alamanni, absorb majority of their territory
Rule of Vandals by King Thrasamund
Estimated date for deposition of the Pomorje B and Pantano Longarini vessels
Roman forces defeat Gepids, Empire gains Sirmium
Franks overtake last of Visigoths holdings in Gaul
Ostrogoths attack Burgundian and Frankish kingdoms; Empire attacks Ostrogothic coastal areas
Ostrogothic King Theodoric rules Visigothic kingdom
Rule of Emperor Justin
Estimated date for deposition of the Marzamemi B vessel
Rule of Vandals by King Hilderic
Estimated date for deposition of the Tantura A vessel
Rule of Visigoths by King Amalaric
Rule of Ostrogoths by King Athalaric
Rule of Emperor Justinian
530-533  Rule of Vandals by King Geilamir
531     Franks under Childerbury and Clothar defeated in Pyrenees; Franks defeat Visigoths in Gaul; Nike revolt
531-548  Rule of Visigoths by Theudis
532-534  Rule of Wessex by King Cerdic
532-537  Construction of church of Hagia Sophia in Constantinople
533     Roman forces conquer Vandal kingdom in North Africa
534     Franks subdue Burgundian kingdom
534-535  Rule of Ostrogoths by King Amalasuntha
534-536  Rule of Ostrogoths by King Theodahad
534-560  Rule of Wessex by King Cynric
536     Franks gain Provence area from Ostrogoths
536-540  Rule of Ostrogoths by King Witigis
537     Construction of Prince of Cologne cathedral begun
539     Franks attack Ostrogothic kingdom
540     Roman forces under Belisarius enter Ravenna, recalled to Persian front
540-541  Rule of Ostrogoths by King Hildibadus
541     Rule of Ostrogoths by King Eraric
541-552  Rule of Ostrogoths by King Totila
542     Bubonic plague spread through Mediterranean; Ostrogoths push through southern Italy, besiege Naples
543     Franks subdue Bavarians; Naples falls to the Ostrogoths
544     Belisarius returns to Ravenna with Roman reinforcements; Bulgars invade Illyricum
545     Roman-Persian peace pact for five years, Rome pays gold tribute; Ostrogoths begin siege of Rome
546     Franks attack Ostrogothic kingdom; Rome falls to Ostrogoths, Roman forces under Belisarius defeated, Ostrogoths abandon city, Belisarius reoccupies; Roman forces in North Africa begin campaign against Moors
547     Construction completed on church of S. Vitale in Ravenna; Roman forces defeat Moors in North Africa
548-551  Roman forces campaigning against Persians in Lazica.
549     Construction completed on church of S. Apollimare in Classe in Ravenna
550     Ostrogoths retake Rome, begin invasion of Sicily; Sclaveni invade Thrace, Dacia, and Dalmatia; estimated date for construction of the church of the Nativity in Bethlehem; estimated date for deposition of the Snape vessel
551     Roman and Persian Empires renew five-year peace pact, Rome pays gold tribute; Roman forces attack Sclaveni and push them pack across Danube
552     Rule of Ostrogoths by King Teias; most Ostrogothic forces defeated by Romans; civil war in Visigothic Hispania
553     Contingent of Roman, Hunnic, and various Germanic and Scythian troops under Narses defeat Ostrogoths in Italy; Franks and Alammani invade Italy
554     Roman forces defeat Franks and Alammani in Italy, gain foothold in southern Hispania
555-567  Rule of Visigoths by Athanagild
556     Roman and Persian Empires renew five-year peace pact, Rome pays gold tribute
559     Contingent of Huns, Bulgars, and Sclaveni invade Macedonia and Thrace, reach Constantinople, repelled and payed tribute
560-591  Rule of Wessex by King Ceawlin
561     Roman and Persian Empires agree to fifty-year peace
565-578  Rule of Emperor Justin II
567-568  Rule of Visigoths by Liuvia of Septimania
567-613  Inter-conflicts between Merovingian kingdoms
568     Lombards pour into northern Italy
568-586  Rule of Visigoths by Leovigild I
570 Visigoths defeat Romans in major battle
571 Visigoths defeat Romans in major battle, Romans continue campaigns to 577
575 Roman forces fail in attack on Lombards
577 Saxons win major victory at Dyrrhachium, defeat Welsh groups
578-582 Rule of Emperor Tiberius II
580-583 Ghassanid confederation breaks apart
582-602 Rule of Emperor Maurice
584 Franks make peace with Lombards
584-590 Rule of Lombards by King Authari
585-593 Rule of Mercia by King Ceoedan
586-601 Rule of Visigoths by Reccared I
590 Construction of ring crypt at S. Peter in Rome
590-616 Rule of Lombards by King Agilulf
591 Peace forged between Roman and Persian Empires, Chosroes cedes Iberia and Armenia
591-597 Rule of Wessex by King Ceol
593 Slavs attack Bavarians
593-606 Rule of Mercia by King Pyrrha
593-618 Rule of Kent by King Aethelberht I
597 St. Augustine voyages to Kent
601-612 Rule of Visigoths by Liuga II
602 Roman army in Balkans revolts, Emperor Maurice killed
602-610 Rule of Emperor Phocas
603 Roman and Persian Empires begin war
606-633 Rule of Mercia by King Ceol
607-610 Persians attack Roman fortifications in Mesopotamia
610-641 Rule of Emperor Heraclius
611-613 Persians conquer Syria
611-643 Rule of Wessex by King Cynegils
612-621 Rule of Visigoths by Sigebut
613 Frankish kingdom briefly united
614 Palestine and Jerusalem taken by Persian forces
615 Estimated date for deposition of the Anse St. Gervais 2 vessel; Reappearance of silver coinage in the East – the hexagram
616 Persian forces invade and control Egypt
616-626 Rule of Lombards by King Adoald
619-620 Shut down of the Imperial mint at Thessalonica
621 Rule of Visigoths by Swinthila
621-631 Rule of Visigoths by Reccared II
622 Mohammed flees Mecca
624 Roman forces operating in transcaucasian region; loss of southern Hispania by Roman Empire at hands of Visigoths
625 Estimated date for deposition of the Yassi Ada vessel
626 Avars take Balkan region from Imperial territory; Persians and Avars combine for siege of Constantinople
626-636 Rule of Lombards by King Arioald
627 Shut down of the Imperial mint at Nicomedia; Roman forces defeat Persians in large battle at Nineveh; Chosroes deposed and murdered in coup
629 Persian forces fully withdrawn from Egypt, Palestine, and Syria, Roman control re-established
630 Roman forces regain city of Jerusalem; estimated date for deposition of the Sutton Hoo vessel; Mohammed returns to Mecca
631-636 Rule of Visigoths by Sisinand
632 Death of Muhammad
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<td>650</td>
<td>Arab forces take all of Iran; Estimated date for deposition of the Dor D vessel</td>
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<td>651</td>
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<td>663</td>
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<td>674-678</td>
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<td>679</td>
<td>Anglo-Saxon kingdoms transfer allegiance from Northumbria to Mercian kingdom</td>
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<td>680-687</td>
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<td>Rule of Wessex by King Caedwalla</td>
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<td>688-700</td>
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<td>688-726</td>
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<td>695</td>
<td>Picts and Scots successfully rebel from Northumbrian kingdom rule</td>
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<td>695-698</td>
<td>Rule of Emperor Leontius</td>
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<td>698</td>
<td>City of Carthage falls to Arab forces</td>
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<td>698-705</td>
<td>Rule of Emperor Tiberius II</td>
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APPENDIX F
GLOSSARY

**Amidships**: A descriptive term that indicates the center portion of a vessel, whether in transverse or horizontal terms. Often refers to the middle of a vessel.

**Aphlastron**: Greek – decorative element found in iconographic examples of vessels; usually comprised of an inverted series of tendrils at the stern of a vessel, projecting inwards.

**Artemon**: Greek – forward sail on Imperial period and Late Antiquity vessels, often depicted projecting over the bow in iconography of the periods.

**Aspect coefficient**: The value derived from dividing a timber’s molded or thickness dimension by its sided or width dimension.

**Beam**: 1) A structural support timber that is positioned transversely in a vessel, typically running from side to side. 2) A term for the maximum width of a vessel.

**Bevel**: The angle or curvature on a section of timber; commonly found on the surfaces of framing timbers.

**Bilge**: 1) Usually the bottom of a vessel up to the transitional portion of its bottom and sides. 2) Can refer to the interior spaces between frames in a vessel’s bottom when in the plural.

**Bilge clamp**: A large ceiling timber fastened to the frames at or just above the bilge area.

**Bolt**: One type of metal fastener usually placed through pre-drilled holes, that is typically round in cross-section.

**Bow**: Referring to the front of a vessel.

**Butt joint**: A planking joint whereby two planks in a strake meet at cuts perpendicular to their longitudinal axes.

**Caprail**: The timbers running along the top of a vessel’s frames forming the uppermost portion of the sides.

**Capstan**: A rotating cylinder typically mounted on a vessel’s deck, turned by shafts extending from the cylinder. This device is used for winding the ropes of nets, affording towing, lifting heavy spars, hoisting anchors, and other such work.

**Carvel**: Ship construction technique whereby hulls strakes are fastened so that their edges are lying adjacent to one another, not overlapping.

**Caulk**: The process of placing or driving material between planking seams in order to increase water tightness of the hull. Such materials are often referred to as ‘caulking’.

**Central Stringers**: Two robust timbers that run along the top of the frames, positioned directly to outside of the keel, and may or may not connect the stem and sternpost. These timbers were also often connected to the frames.
Ceiling: Planking lying on the interior surface of frames within a vessel’s hold.

Chamfer: A flat surface obtained from removing the corner edge of a squared timber.

Chine: The area of a hull where a sharp angle is formed by the side and bottom of a vessel.

Clamp: Often a thick ceiling strake, attached to the frames, and often located behind the upper wales. It was typical for decking structures to be secured to clamps.

Clinker: Refers to a lapstrake-type construction technique whereby planks overlap one another and are fasted with rivets or nails. However, for purposes of this work, the term ‘lapstrake’ will be used as descriptive term for all overlapping strakes regardless of fastening.

Collegia: Latin – group of investors and shippers during the Imperial period whose operation typically specialized in one or two types of goods.

Curved scarf [S-scarf]: A planking joint whereby two planks in a strake meet at cuts that form an ‘S’ shape through a curved cut of their ends.

Deadrise: The angle of rise of the frames off of the keel; or the difference in height of the top of the keel and the bilge.

Deck projection: The extension of the deck beyond at the stern of a vessel beyond the sternpost.

Deck structure: Housings, platforms, or other structures that extend above a vessel’s topmost deck.

Denarius: Silver coin issued during the Roman Imperial and Late Antiquity periods.

Dunnage: Plant or other material used to line the interior of a vessel’s hold to decrease the damage to containers through shifting, and to protect the vessel’s timbers from the cargo.

False Keel: A timber attached to the outside of a keel that protects the keel from impacts, and can be designed to provide additional strength to the keel.

Flat scarf: A planking joint whereby two planks in a strake meet at cuts that form an angle off of their longitudinal line, however not perpendicular (see Butt scarf).

Floor timber: Refers to a framing timber that runs over the keel and covers the width of the vessel’s bottom.

Follies: Copper coin issued during Late Antiquity.

Forecastle: For Late Antiquity, any structure that is located in the prow of a vessel.

Forequarter: The forward portion of a vessel’s hull from amidships to the bow.

Frame Station: This analytical term refers to an area along the hull and keel where a set of framing timbers lie. It can consist of any combination of floor timbers, half-frames, and/or futtocks.

Framing Timber (Frame): A transverse support timber (or several connected timbers) whose length runs perpendicular to a vessel’s long axis. These timbers were often attached to the keel in Late Antiquity, and always attached to the planking.
Futtock: Refers to a framing timber that extends the length of a floor timber, although it was rarely attached to a floor timber in Late Antiquity.

Galley: 1) One type of vessel that was primarily oar propelled, but may have also utilized sail. 2) The area or compartment within a vessel where meals were prepared.

Garboard: The first strake on each side of a vessel that lies adjacent to the keel. In a flat-bottomed vessel, the lowest side strake is considered the garboard.

Half-frame: Refers to a framing timber that begins at the keel and extends primarily to one side of the vessel only. In some instances the half-frame may cross the keel for a short distance.

Hogging: The condition of a hull whereby its ends are forced downward and its center upwards.

Hook scarf: A joint whereby two timbers (other than planking strakes) are joined with complex interlocking cuts that can be further secured with the insertion of a key (keyed-hook scarf).

Keel: The central longitudinal timber in a vessel’s hull, positioned at the lowest point of the bottom.

Keel plank: Inordinately wide and thick planks positioned along the central longitudinal axis of a ship’s hull, positioned at the lowest point of the bottom.

Keelson: A robust timber that runs along the top of the frames, positioned directly over the keel, and connects the stern and sternpost. This timber was also often connected through the frames to the keel.

Lapstrake-type construction: A method whereby the upper planking timber’s edge overlaps the one below it a small amount. This is a general descriptive term for this work and ignores differentiation by methods of fastening. See Clinker.

Length-to-beam coefficient: The value derived from dividing a ship’s total length by its total beam.

Limber holes: Notches cut into the underside of frames that allowed the flow of bilge water along the bottom of a vessel.

Mast partners: Timbers used to reinforce the opening in decks on which the mast would rest, thereby absorbing much of the force.

Maststep: A robust timber in which a notch (or seat) was cut for the heel of the mast to sit. This timber was often notched into central stringers or built into a series of proto-keelson timbers during Late Antiquity.

Materiariorius: Latin - seller of raw materials in the Roman Empire.

Midship: An adjective to refer to the amidships area of a vessel. Often used to qualify a timber or fitting as being near the middle of the vessel.

Molded: A term that refers to a timbers dimension taken from its top to bottom surfaces.

Mortise: Refers to any notch cut or carved into a face of a timber.

Mortise-and-tenon joint: One type of timber joint whereby a tenon is situated inside two opposing mortises on the joined timbers.
Nail: A small metal fastener used to join timbers to one another. Typically had a sharp point on one end and a flat head on the opposite end that allowed it to be driven through the wood. These could be round or square in cross-section.

Navicularii lignarii: Latin - shippers of timber in the Roman Empire.

Negotiator: Special officials who were attached to royal courts and abbeys of both the Eastern and Western Empires. Their responsibilities included the organizing of supplies, the marketing of surpluses, and the overseeing of the grain supply in large cities.

Nummus: Copper coin issued during Late Antiquity.

Oared: Refers to the type of propulsion a vessel utilizes; the oar is affixed to an oarlock that allows it to pivot, and thus providing significant leverage and additional propulsive power.

Oculus: Latin – design typically painted on the fore quarter of vessels that resembles an eye.

Paddled: Refers to a type of propulsion a vessel utilizes; the paddle is held in a rower’s hand, thus all leverage and power is from the individual alone.

Peg: A small dowel that was typically used to lock tenons into position in their mortises. It was driven through a pre-driven hole.

Plank: Specifically a hull timber that forms the bottom and sides of a vessel. One or more planks make up a planking strake. Planks thus vary in their lengths and widths.

Port: Refers to the left side of a vessel, or describes any element on the left side, when facing forward in the vessel.

Post: Either the stem or sternpost of a vessel.

Proto-keelson: A robust timber(s) that runs along the top of the frames, positioned directly over the keel, but does not connect the stem and sternpost. This timber was also often connected through the frames to the keel. Often in Late Antiquity there were two timbers, one each running from the stem and sternpost, which did not meet one another.

Prow: The extreme front section of a vessel.

Quarter rudder: A timber(s) that was attached to one or both sides of the vessel at the stem, enabling a helmsman to maneuver the vessel in a desired direction. The helmsman typically held the ‘tiller’ that was attached to the rudder’s ‘shaft’. At the water end of the shaft, ‘blades’ were attached.

Rabbet: One type of cut along a timber that allowed another timber to fit together more snugly. For example, keels often had rabbets cut into their upper edges to allow a tighter fit with the garboard strake.

Ram: Associated with warships, a ram was probably a complex of timbers, likely often sheathed in metal, that was integrated into the bow of a vessel anywhere from just below to just above the waterline. It may have been used for inflicting damage on another vessel’s hull or oars.

Sagging: The condition of a hull whereby its center is forced downward and its ends upward.

Scarf: The intersection of two timbers whereby their dimensions are not increased.
Screen: One type of defensive structure used on vessels. Comprised of wood, matting, or shields, screens ran along the sides of vessels just above the caprail and protected rowers and soldiers from missile fire.

Sided: A term that refers to a timbers dimension taken from one side surface to the other.

Solidus: Gold coin issued during the Roman Imperial and Late Antiquity periods.

Spike: A large metal fastener used to join timbers to one another. Typically had a sharp point on one end and a flat head on the opposite end that allowed it to be driven through the wood. These could be round or square in cross-section.

Stanchion: A timber that had its long axis situated vertically in the vessel, enabling it to support deck structures or beams.

Starboard: Refers to the right side of a vessel, or describes any element on the right side, when facing forward in the vessel.

Steering oar: Typically used with smaller vessels, this was an oar that was laid over the stern or stern quarter and used by the helmsman to maneuver the vessel in a desired direction.

Stem: 1) A timber, usually scarfed to the keel, that continued the keel forward and upward, to which most of the strake ends were attached. Hence it was the forward-most timber in a hull of Late Antiquity. 2) Often used as a general term for the extreme front of a vessel.

Stern: Often used as a general term for the rear of a vessel.

Sternpost: A timber, usually scarfed to the keel, that continued the keel rearward and upward, to which most of the strake ends were attached. Hence it was the rear-most timber in a hull of Late Antiquity.

Strake: Specifically a hull timber(s) that forms the bottom and sides of a vessel, and is comprised of one or more planks. Hence, strakes ran the length of the vessel from stem to sternpost.

Stringer: Rather robust timbers that lie atop the frames and run parallel to the vessel’s long axis. These timbers were attached to or through the frames in order to increase a vessel’s longitudinal stiffening.

Tenon: A small, thin, often symmetrical, tongue of wood that was inserted in mortises as part of a mortise-and-tenon joint. These tenons were sometimes held in place with pegs.

Tholepin: A dowel extending above the caprail or other wale to which an oar was affixed and thus provided a pivot point.

Through-beam: A beam timber that pierced the hull and extended outboard of it. These were typically found high in the hull.

Thunderbolt of Jupiter: One of the most complex and commonly used keyed-hook scarf in Late Antiquity.

Timbers: Wood members or composite structures that formed a vessel.

Treenail: A larger wooden dowel that was used to attach timbers to one another by driving it through a pre-drilled hole.
Tremisses: Gold coin issued during Late Antiquity.

Turn of the bilge: The area of a hull where the bottom makes its transition into the sides.

Volute: Decoration of spiral shape at the top of a ship’s post.

Wale: Any robust strake, significantly thicker than the planking, that runs from stem to sternpost. These timbers provided increased stiffening for a vessel.
VITA

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