EXTRACTING CULTURAL INFORMATION FROM SHIP TIMBER

A Dissertation

by

PEARCE PAUL CREASMAN

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

December 2010

Major Subject: Anthropology

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ABSTRACT

Extracting Cultural Information from Ship Timber. (December 2010) Pearce Paul Creasman, B.A., University of Maine; M.A., Texas A&M University Chair of Advisory Committee: Dr. Filipe Vieira de Castro

This dissertation is rooted in one general question: what can the wood from ships reveal about the people and cultures who built them? Shipwrecks are only the last chapter of a complex story, and while the last fifty years of nautical archaeology have rewritten a number of these chapters, much of the information unrelated to a ship's final voyage remains a mystery. However, portions of that mystery can be exposed by an examination of the timbers.

An approach for the cultural investigation of ship timbers is presented and attempts are made to establish the most reliable information possible from the largely unheralded treasures of underwater excavations: timbers. By combining the written record, iconographic record, and the social, economic, and political factors with the archaeological record a more complete analysis of the cultural implications of ship and boat timbers is possible. I test the effectiveness of the approach in three varied casestudies to demonstrate its limits and usefulness: ancient Egypt's Middle Kingdom, the Mediterranean under Athenian influence, and Portugal and the Iberian Peninsula during the Discoveries. The results of these studies demonstrate how ship timbers can be studied in order to better understand the people who built the vessels.

DEDICATION

To my parents.

ACKNOWLEDGEMENTS

Many people have contributed to the successful completion of this work, but it is only appropriate that I begin by acknowledging my chair, Filipe Castro. To say he has been provocative would be an understatement. His interminable support and encouragement throughout my graduate studies deserve more than a simple "thank you." The remainder of my career will have been influenced by the training and guidance which he has supplied. Filipe kept me grounded but encouraged me to learn more, for which I am most grateful. I hope to be able to provide a good return on his investment.

I would like to thank Diana Burton for her warm welcome to a student who somehow showed up on her academic doorstep. I walk away having gained greatly from our conversations, both personally and academically. Some of the most pleasant times over the past five years have been my walks back across campus after having visited her, reflecting on our discussions.

Deborah Carlson is owed considerable thanks for helping me transition from "student" to "peer." I am thankful that she has always, in my opinion, treated me as colleague. Her expectations for this work and frank critiques have forced me to raise the level of rigor in my research. I will always ask "what will make this better?"

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I must also acknowledge the contributions of my unofficial committee members: Francisco Contente Domingues. He has proved a phenomenal source of historical information. Steve Smith's substitution at the defense made this possible, and Richard Furuta's willingness to substitute put my mind at ease during an uneasy time.

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CHAPTER I

INTRODUCTION

The role that seafaring played in the discovery and conquest of the world should not be underestimated. Whether it was trade and exploration on the Nile River in ancient Egypt that first opened the interior of Africa to the Mediterranean world or the exploits of Spain across the Atlantic to "discover" the New World, there is one common thread: wooden ships and boats.¹



Figure 1. Basic shape of a ship's hull (bow at right) in raw timber (after Ballu 2000, 20).

Any study of the vessels that shaped the world in which we live is incomplete without an understanding of the resources required to construct them: specifically, wood (Fig. 1). Since timber has in all ages been an important commodity it has been exploited

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

¹ Creasman 2005, 1; see also Creasman 2008, 235-6.

and manipulated.² Throughout history, the restrictions of timber reserves have often dictated politics,³ military tactics,⁴ social relations,⁵ and economics.⁶ Such stresses on resources often caused or contributed to lasting modifications in ship construction,⁷ which are visible in the material record today.⁸ Not infrequently, these modifications caused or contributed to the demise of the ship itself. In short, maritime prowess is and has always been dependent on access to the terrestrial products from which ships are made.⁹

This dissertation is rooted in one question: What can the wood from ships reveal about the people and cultures who built them? One of the basic premises of archaeology is that when an object is modified by a person, evidence remains of his or her presence, thought processes, and culture. The research presented here indicates that ship timbers are individual artifacts that can be studied to expose the cultural information they

² Haneca et al. 2009, 7; see also Perlin (1989) for an introduction to the history of wood use.

³ For example, Borza (1987, 47) states, "the control of and access to the timber resources of Macedon were for at least a century and a half not only pawns in the diplomatic game between Macedon and Athens, but also major factors influencing the political and military decisions of several other states during the Classical period."

⁴ See Corvol and Amat (1994) and McNeill (2004) for reviews of the role of woods in war; control of the island of Crete and its fast-growing cypress (*Cupressus sempervierens*) forests was a major advantage for the Byzantines in their quest for maritime supremacy over the Arabs (Unger 1980, 55 n. 1; Bill 1994, 151). ⁵ Timber has, on many occasions, been used as bribes, bridewealth, and other means of social mediation.

For example, Mark Antony's gift of Cilician forests to Cleopatra VII as source for ship timber, ca.36 B.C.E. (Strabo *Geography* 14.5.3; see Jones 1929).

⁶ If there is any doubt, see Meiggs' chapter titled "The Timber Trade" (1982, 325-70), Gale et al.'s summary of wood in ancient Egypt (2000, 334-710), or Horden and Purcell's economic and social analysis, especially the section titled "The Integrated Mediterranean Forest" (2000, 182-6). ⁷ Bill 1994, 151; Creasman 2008, 236.

⁸ Too many ships to list here have employed "inferior" species or cuts for essential components, such as keels and masts. For example, see the discussion of the Pepper Wreck's frames in Chapter VI of this dissertation.

⁹ Lane 1975, 217; cf. Albion 1926.

contain; not just their origin, species, date, or preference in construction.¹⁰ For example, on some ancient Egyptian timbers, tool marks are so well preserved that different sizes of chisels, saws, and adzes used to shape the timbers can be identified and a shipbuilding tool kit effectively reconstructed.¹¹ Similarly, the management of ship timber stands can be reconstructed by looking at the arcs of futtocks, relative age of common timber pieces, percentage of wood wasted, and the identification of "waney edges."¹² Even the size, shape, and quality of timbers can reveal data about resource availability and construction method.¹³ From these and other observations a general concept of timber management can be inferred. Inference combined with written records yields a more detailed understanding of the cultural and technical information that ship timbers have to offer. Simply stated, ship timbers are objects of material culture that have much to offer beyond the scope of a ship's final voyage or trade route.

Well over 6,000 years of wooden shipbuilding in the Western world preceded the adoption of iron as the primary construction material.¹⁴ A complete understanding of the changes in European and Mediterranean shipbuilding over this time should include an investigation and discussion of the basic building material, its properties, how it was acquired, how it was or was not maintained as a sustainable resource, and the effects this maintenance may have had on shipbuilding.

¹⁰ Throughout this dissertation, I use the phrase "ship timber(s)" for convenience, but this should be considered to include potentially any watercraft that employed wood in their construction, including ships, boats, barges, rafts, dugouts, etc.

¹¹ Ward 2000; this is also the case for many other periods and places.

¹² Loewen 2000; waney edges are phenomena that are best understood by seeing them, as they are difficult to describe or capture on film; see figure 10 in this dissertation.

¹³ As Castro (2005, 182-8) indicates regarding the likely *Nossa Senhora dos Martires*, or "The Pepper Wreck."

¹⁴ The end of the great wooden ship battles is generally considered to be the Battle of Hampton Roads in 1862 C.E. (Watts 1996, 207-10; see also Konstam and Hook 2002).

A study of the timbers alone is too limiting if attempted outside the economic frames of their respective periods. Choice shipbuilding timber has long been expensive, even in regions with ample local resources. Harvesting, transporting, storing, and preparing the timbers were time and labor intensive. With technological advents, which arose to mitigate time and labor investments, ships generally became more complex, larger, or were built in greater numbers. More ships required more timber, unless technological gains offset consumption. Most societies with a shipbuilding industry had what can be considered a "timber economy,"¹⁵ that is, methods of managing and acquiring wood for ship construction. Many aspects of the timber economy are reflected in the hull timbers themselves (origin, shape, size, general quality, etc.), and are discussed in the following chapters.

This dissertation poses and address questions that evaluate what ship timbers can reveal about the people and cultures who built them. The intent is to describe current methods of investigation, map areas of ignorance, ask fresh methodological and theoretical questions, and identify interdisciplinary areas of potential for extracting cultural information from a group of ship timbers. A methodological framework that can be explored or performed on any collection of ship timbers is provided and assessed to clarify what can, or cannot, be gained from such an analysis. Several resources exist to aid in a cultural study of ship timber beyond the visually observable material record,

¹⁵ Outside those specifically discussed in this dissertation, few thorough investigations of shipbuilding timber economies have appeared. The Baltic (Wazny 1992, 2005; Indruszewski et al. 2006; Daly 2007) and Venetian Republic (Lane 1933, 1973, 1975) will be discussed briefly in Chapter II. Otherwise, early America (Bamford 1952; Wrigley 1962; Wood 1995; especially Leavenworth 1999) and the British Royal Navy (Albion 1929; Atkinson 2007; Baker 2002; Knight 1993, 1986; Roche 1987) have received some attention.

including chemical analyses, the written record, iconography, and in some cases ethnographic studies. Treatises on shipbuilding, for example, often neglect many of the practical aspects of the art that the material record can help reveal. Many of the day-today methods used by shipbuilders would have been considered common knowledge and may have gone unrecorded for a variety of reasons (much of the practice was likely considered trade secrets, passed from master to apprentice), but evidence of these methods remains in the shape, placement, and character of the timbers themselves.¹⁶

Specific questions addressed in this dissertation include: how do scholars look at timber and what information can or should be retrieved; what can we learn from shipwrecks about timber use in a given society; what methods can be included in a cultural investigation of ship timbers, and what are the expectations and limitations of such methods?

Further investigations, largely outside the scope of this work, could yield much information about the timber economy of a seafaring society. Few attempts have been made to answer the following questions: what are the stand dynamics for trees intended for shipbuilding;¹⁷ what is the minimum useful age ("economic maturity") of trees employed in shipbuilding;¹⁸ how much maintenance of a timber stand is needed to be ideal for ship construction; was multigenerational maintenance a family or community

¹⁶ See Loewen 2000; see also Harriot (n.d.) for a candid glimpse into late-16th and early-17th century wooden ship construction.

¹⁷ No investigations of this particular question are known to the author, although useful studies of regional and temporal forestation can be applied for these purposes. Cyprus (Thirgood 1987; Butzer and Harris 2007) and Israel (Liphschitz 2007) in the Classical period have received much attention and serve as illustrative examples, as does the Alentejo region in Portugal (Figueiral 1996; da Silva 2001).

¹⁸ Several authors have made note of this in passing, or pondered, but few have addressed the issue (see Rival 1991; Pomey 1998; Loewen 2000; Guibal and Pomey 2003).

effort, or did a community just use what nature provided; how far away does timber come; how many square feet of timber are required per compass timber or plank;¹⁹ how many hours does it take to produce a hull plank, frame timber, keel, etc.?

Although study of ships and timber can encompass the many millennia since humanity first ventured out onto the water, this work will employ three case studies to evaluate the cultural interpretation of ship timber. The following periods have been chosen because each one presents a unique combination of challenges and opportunities for interpretation: ancient Egypt during the Middle Kingdom, the classical Mediterranean under Athenian influence, and Portugal during the Age of Discovery. The latter two periods have considerable written records and limited hull remains, while the first has limited written records and a comparatively large archaeological sample of ships, boats, and timber. The contributions and limitations of each period will be outlined in a dedicated section and are briefly discussed below. I chose these places and times in part because each case study represents a critical period in the history of Western shipbuilding and has benefited from decades of study and excavation.

Ancient Egypt has been chosen because it is the traditional beginning for a discussion of the history of Western shipbuilding and it is a great example of a seafaring culture managing scarce native timber resources.²⁰ Within ancient Egypt I will focus on the Middle Kingdom (2055-1650 B.C.E.) for its corpus of archaeological information,

¹⁹ This question has previously been investigated, to varying depths, and can be evaluated in three categories: 1) analysis of recent ships, from approximately 1800 C.E. and later (for example, Daboll 1863; Lower 1933); 2) reference to manuscripts and contemporary sources, such as Theophrastus' *Historia plantarum* (Hort 1999), Barkham's investigation of Basque tax records and contracts (1981), or Ballu's analysis of French naval timber from the 17th to 19th centuries (2003); and 3) reconstructions and information borne from them (Morrison et al. 2000; Croome 2005).

²⁰ Creasman 2005, 4; see also Bass 1972, 12-36; Steffy 1994, 23-37; Throckmorton 1987, 8.

which includes four nearly complete 12th Dynasty vessels collectively known as the Dahshur Boats, a series of robust timbers that appear to be ships' frames from Lisht, numerous boat models (including one of the most heralded sets from ancient Egypt, buried with the 11th Dynasty nobleman Meketre) and a model of a carpentry shop, and two likely Red Sea ports with timber remains at Ayn Soukhna and Mersa Gawasis. Boatbuilding and boat use iconography, as well as some written accounts of trade and war also exist for the period. My previous research focus on this region and period allows for a particularly detailed discussion.²¹

Athens in the 5th century (499-400) B.C.E. represents the cultural zenith of the Classical period and has been chosen both for its comparative abundance of written records and because it was home to a seafaring society whose authority was dependent upon ships. The extensive terrestrial excavations over much of the mainland and the Aegean islands should prove useful in acquiring contemporary data for local timber resources. The excavation and publication of at least five shipwrecks with hull remains from the period will be an important resource for this endeavor.

The Iberian Peninsula during the Age of Discovery (1400-1600 C.E.) provides perhaps the most comprehensive pool of data from which to make a study of ship timber. The ships from the Iberian Peninsula during this time opened the world to Europe, defining the way history developed thereafter. With a focus on Portugal, several treatises on shipbuilding, historical documents, shipwrecks with published hull remains,

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²¹ Creasman forthcoming; Creasman and Doyle 2010; Creasman et al. 2010; Creasman et al. 2009; Creasman 2005.

terrestrial excavations, contemporary histories, tax records, some ethnographic works, and extensive recent scholarship are all available for analysis.²²

Several other periods were considered but eliminated from this study. Although already at least partly studied, imperial Rome, the Italian Renaissance, the Dutch during the time of the Dutch East India Company (V.O.C.), the French Enlightenment, or the British Empire in the 18th century would have each been relevant case studies and are worth developing and investigating in the future. Rival's work with Roman vessels,²³ Lane's with the Italian city-states,²⁴ Hoving's work in the Netherlands,²⁵ Bamford's and Ballu's with the French,²⁶ and Albion's work regarding the English²⁷ have addressed parts of the subject of timber resources. However, no holistic method for ship-timber investigations is evidenced in these studies.

In order to develop a more complete understanding of the analysis of ship timbers, a thorough literature review follows this introduction, primarily focused on the methodological and technical studies of ship timber. After this review, a section on timber analysis outlines the uses of several methods and their specific application to the cultural interpretation of ship timber, including dendroarchaeology, radiocarbon analysis, palynological analysis, deoxyribonucleic acid (DNA), and other emerging methods. While the benefits and limits of dendrochronology are largely well defined,²⁸

²² Such as Oliveira's *O livro fábrica das naus*, ca. 1580; Lavanha's *Livro primeiro da architectura naval*, ca. 1610.

²³ Rival 1991; aided by Meiggs (1980, 1982); see also Hanson 1978, 293-305.

²⁴ Lane 1973, 1975.

²⁵ Hoving 1996.

²⁶ Bamford 1956, 1952; Ballu 2003.

²⁷ Albion 1926; see also Greeley 1925; Carroll 1981.

²⁸ See Kuniholm 2002, 2001b, 1982.

the field of dendroarchaeology largely remains to be applied to ship timbers. The case for radiocarbon or ¹⁴C dating was long ago confirmed.²⁹ Pollen analysis, while certainly familiar in an archaeological context,³⁰ has had little application in the study of ship timber, mainly due to disturbed sediments and loss of pollen spores under water.³¹ Extracting and analyzing DNA from waterlogged wood, in the event any survives, is extremely difficult and has only recently been explored for oaks.³² Infrared thermography and ultrasonic velocity assessments have recently been applied to structural timbers in historic buildings, and can prove similarly useful for structural timbers in ships.³³

Further study will investigate how far certain types of ship timber were known to travel (for example, Levantine cedar, *Cedrus libani*, in the ancient Mediterranean saw few boundaries, while Egyptian sidder, Ziziphus sp., is not known to have regularly left the banks of the Nile as a ship construction material).³⁴ Comparison of reconstructed historical distribution maps with modern ones may also help fill in the gaps where pollen analysis is unavailable or unreliable, but it lies outside the scope of this work.

This dissertation presents an approach for the study of ship timbers and attempts to establish the most reliable information possible from the largely unheralded treasures of underwater excavations: timbers. By introducing the written record, iconographic record, and the social, economic, and political factors to the archaeological record a

³³ Kandemir-Yucel et al. 2007.

 ²⁹ Taylor 1987.
³⁰ Marshall 2007; see also Faegri and Iverson 1989.

³¹ Giachi et al. 2003.

³² Petit et al. 2002a; Deguilloux et al. 2002; Deguilloux et al. 2003; Cottrell et al. 2004.

³⁴ The Kinneret boat, ca. 1st century C.E., had a keel component made of Christ thorn, *Ziziphus spina*christi, but the wood is likely to have come from the Levant (Wachsmann 2000, 252).

more complete analysis of the cultural implications of ships and boats is possible. Wood was one of the most valuable resources for many of the world's greatest civilizations, and when thoroughly studied it is a valuable tool in growing our understanding of societies.

Applying the methods mentioned above, and as described in the following chapters, to each case study validates and poses caveats regarding the final understanding produced in this dissertation. The conclusion notes how ship timbers can be studied in order to better understand the people who built the vessels.

CHAPTER II

LITERATURE REVIEW

Any study of maritime archaeological or historical wood, forests, or timber should begin with two references: Robert G. Albion's Forests and Sea Power and Russell Meiggs' Trees and Timber in the Ancient Mediterranean World.³⁵ Albion was the first to intensively explore naval history through the filter of the forests. Later, Meiggs took this concept and produced a brilliant addendum to the study of the ancient Mediterranean. Meiggs states that "... the most spectacular addition to the corpus of ancient timbers has come from the development of underwater archaeology."³⁶ Despite this praise and a chapter labeled "Forests and Fleets," Meiggs mentions just two archaeologically excavated shipwrecks in his entire masterpiece and these only in passing.³⁷ He cannot be faulted, as his chosen task was epic, and at the time he was writing the discipline of nautical archaeology was still in its infancy. Both Albion's and Meiggs' works are imminently useful, but the growth of nautical archaeology and the plethora of shipwrecks excavated since they wrote have necessitated an update and expansion of their studies. Twenty years later, at the turn of the recent millennium, the field of nautical archaeology was still viewed by at least one prominent botanist and historian, and overlooked by many others, as having great *potential* to add to the

³⁵ Albion 1926; Meiggs 1982.

³⁶ Meiggs 1982, 14.

³⁷ 1) "...a fourth-century B.C.E. merchantman sunk off the north coast of Cyprus..." (Meiggs 1982, 14) can refer only to the Kyrenia ship. Although the interim hull report was not formally published until 1989 (Steffy), through the works of Michael Katzev (for example 1967, 1970, 1972, 1980), the wreck's existence was widely known, certainly among scholars, by *Trees and Timber's* 1982 publication date; 2) "...a [Punic] ship sunk off the north-western shore of Sicily..." (Meiggs 1982, 142-3) is the Marsala Punic warship, discovered in 1972 (Frost 1972, 1976).

knowledge of history through the analysis of hull timbers.³⁸ That the discipline was viewed as potentially beneficial only a few years ago confirms that further work is needed.

Since archaeologists began excavating shipwrecks underwater in 1960,³⁹ the study of wooden ships has illuminated several branches of information critical to the analysis and understanding of human behavior. Fifty years later, the heart of nautical archaeology remains the study of ship construction, trade, and diffusion. Based on the nature of the evidence under study (that is, wooden ships), it is surprising that environmental and natural resource economics⁴⁰ studies have been overlooked, especially given their prominence in related fields. Similarly, the study of wooden ships still has much to offer in the analysis of human behavior and the environment. Although varied approaches have been applied to the interpretation of ship timber, a lack of procedural and interpretive precepts and standards hinders widespread application of results.⁴¹ Fortunately, ship timber studies have an advantage over one of the primary concerns which other studies of archaeological wood encounter: wood use.⁴² Studying ship construction lends itself to a necessary understanding of wood-use patterns in the hull of a ship, and a plethora of studies have attempted to understand these trends over time and regions. Yet, "the more we understand the behavior involved in wood

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³⁸ For one example see Rackham 2001, 14.

³⁹ Bass 1967; see also Throckmorton 1962.

⁴⁰ See Solow 2009; Tietenberg 2005.

⁴¹ Nautical archaeology and the study of human behavior has run into many of the same concerns as Dean (1996, 461-69) found with dendrochronology and the study of human behavior, especially the "old wood problem."

⁴² See Towner and Creasman (forthcoming) for an example of archaeological wood use; Towner 2007, 2307-15.

procurement...discard and consumption, the better we will be able...⁴³ to understand the impact of a shipbuilding society upon its surrounding environment.

The extant body of work elucidating cultural practices involving timber and wood from the analysis of ship timber is small. While several works include chapters regarding ship timbers, especially regarding vessels from northern Europe, there are only a few extensive works on this topic, of which three stand as particularly relevant for this study: Meiggs' *Trees and Timber*, Michel Rival's *La Charpenterie Navale Romaine*, and Frederic C. Lane's *Venice a Maritime Republic*.⁴⁴ While Lane framed parts of his work within the context of ship construction, neither his nor Meiggs' work were written recently enough to take advantage of the contributions of the field of nautical archaeology. Written more recently, Rival focuses on three archaeologically excavated ships.

Lane, a historian, concentrates on the role of state regulation and the economic model of supply and demand in Venice that archaeological timber studies should be able to evaluate but have not. This is in no small part due to the fact that "Medieval ships remains are scant...those vessels that have been discovered are rarely complete and often have not been properly excavated and published."⁴⁵ Lane describes the sources of Venetian shipbuilding timber at length in a chapter titled "Timber Supplies,"⁴⁶ which would make for an ideal baseline from which archaeological remains could be interpreted. When combined with the works of Furio Ciciliot, who focuses on Genoa in

⁴³ Dean 1996, 466; Dean does not address ships, but human/environment interactions, which I have applied to shipbuilding.

⁴⁴ Meiggs 1982; Rival 1991; Lane 1975.

⁴⁵ Martin 2001, 4.

⁴⁶ Lane 1975, 213-33.

the same period, a regional understanding of this resource and its use may be possible.⁴⁷ If more ships from the period can be identified and properly excavated, an evaluation of Lane's historical reconstructions of ship timber could be exceptionally revealing.

For example, the Republic of Venice is reputed to have had the first strict forest conservationist laws, appearing in the late 13th century.⁴⁸ The Venetian state floated timber down rivers with checkpoints imposed at towns, such as Verona, where no load could pass without a Venetian official's approval.⁴⁹ By the 15th century Venice had consumed the locally available choice forest reserves, probably for ships, buildings, and conversion to arable land.⁵⁰ Soon thereafter, the cost of obtaining quality shipbuilding wood increased substantially,⁵¹ and for a city so dependent on its shipping trades a crash of the shipping industry would have been calamitous. If these practices had continued, by the 16th century, even the nearby Alps would not have satisfied their timber needs, so the Arsenal took forest management policy into its own hands.⁵² They had to look to the eastern side of the Adriatic, Crete, and elsewhere for quality shipbuilding timbers.⁵³ In order to maintain revenue, the state instituted a ban on the purchase of foreign ships,⁵⁴ but this placed greater pressure on local timber sources, as few merchants could afford to import timber, and then build ships. Perhaps this was a method of leaving the best foreign reserves for use and acquisition by the Arsenal. This scenario has yet to have

⁴⁷ See Chapter III; Especially the chapter regarding raw materials in his seminal work about shipbuilding in Genoa (Ciciliot 2005, 27-72; discussion of wood on pages 27-50); see also Ciciliot 2002, 2000a, 1999, 1993.

⁴⁸ Perlin 1989, 147.

⁴⁹ Perlin 1989, 147.

⁵⁰ Lane 1973, 378-9.

⁵¹ Due to supply, demand and direct and indirect costs (Lane 1973, 378).

⁵² Lane 1975, 227.

⁵³ Lane 1965, 204-16; Meiggs 1982, 384.

⁵⁴ Lane 1973, 379.

been borne out by investigations of Venetian ship timbers, but the discovery of future hulls could facilitate an analysis of such historical reconstructions. Was the state effective in its prohibitions? Was the cost of the Venetian splendor and sovereignty the bareness of its coastlands?⁵⁵

There is no shortage of praise for Meiggs' compilation of references to timber from ancient written records,⁵⁶ and it is merited. Shortly after Meiggs, an economic historian, published his *opus* in which written records of ships and timber figure prominently, Eugene Borza, also a historian, expanded on a portion of the work. Borza addressed the relationship between Aegean timber reserves and politics during the height of Athenian influence.⁵⁷ Recently, Oliver Rackham, a botanist by training, endeavored to incorporate archaeological remains into the discussion of ancient Greek timber, but he is decidedly pessimistic about the meaningful inclusion of shipwrecks.⁵⁸

Rival supplements Meiggs' historical approach⁵⁹ and presents an in-depth study of Greco-Roman ships (emphasis on Roman), their construction, and timber, perhaps as if he were a shipwright himself. He describes typical Mediterranean trees and their usefulness in shipbuilding, and maps where they can be found.⁶⁰ This study offers the earliest holistic attempt to understand ships and timber from an archaeological view.

⁵⁵ Darby 1956, 187.

⁵⁶ Lionel Casson wrote: "This is a comprehensive and authoritative contribution done with the careful scholarship and balanced judgment characteristic of all [Meiggs'] work" (1984, 322).

⁵⁷ Borza 1987.

⁵⁸ Rackham 2001, 14.

⁵⁹ Here, Rival benefitted not only from Meiggs' *Trees and Timber* (1982), but from an earlier work as well "Sea-borne timber supplies to Rome" (1980).

⁶⁰ Rival 1981, 11-98.

Despite a small sample size of 19 wrecks of which 3 (Madrague de Giens,⁶¹ Place de La Bourse in Marseilles,⁶² Port Vendres I⁶³) are the main foci, he progresses towards an understanding of such essential questions as identifying the shipyard where a hull was built. Rival's conclusions about the Roman timber economy are especially interesting from a cultural perspective. Despite that certain species were known to have better shipbuilding qualities (as evidenced by writers of the period), "inferior" species were employed in construction more often than not. A subsequent study by Michael Fitzgerald⁶⁴ with a much larger sample supports Rival's interpretation. The "ideal" shipbuilding timber from contemporary texts, fir (*Abies* sp.),⁶⁵ is evidenced in the planks and frames of only five of approximately 50 wrecks surveyed.⁶⁶ Rival's explanation is inherently practical: species were chosen based not on an ideal but on availability, the logistics of acquisition, and then, all other factors being equal, performance characteristics.⁶⁷ Unfortunately, subsequent works on the period have not advanced other facets of Rival's work.⁶⁸

Other ship specialists, to be discussed below, have also dedicated works to a cultural, socio-economic, or environmental understanding of timbers, including: Furio Ciciliot, Brad Loewen, Seán McGrail, and Cemal Pulak. Joe Flatman suggests that such

⁶¹ Pomey 1982, 133-54; Tchernia et al. 1978.

⁶² Pomey 1988, 397-412; Gassend 1985, 115-27; Gassend 1982, 269-83.

⁶³ Liou 1974, 414-33.

⁶⁴ Fitzgerald 1994.

⁶⁵ See Meiggs 1982, 118-9.

⁶⁶ Fitzgerald 1994, table VI.1; see also Appendix.

 ⁶⁷ If confirmed on a larger scale, this trend could have interesting implications when considered in connection with Horden and Purcell's discussion of high and low commerce, specifically cabotage (2000).
⁶⁸ For example, Ulrich's *Roman Woodworking* (2007) neglects a discussion of ships and notes only a few individual wrecks in passing, the Nemi Barges being the most prevalent.

studies have been an extremely recent advent for ships found in the United Kingdom.⁶⁹ The earliest is Nigel Nayling's *Magor Pill Medieval Wreck* report in 1998, with little else until 2004 by way of Peter Clark's *Dover Bronze Age Boat*. Although these are important contributions as they recognized that timbers could be used to better understand culture, these reports provide little methodological grounding for my research. Like Flatman, I will address the smaller-scale contributions generally by region, which supports a holistic understanding, relative to the local environments.

Regional and Topical Analyses

Western Mediterranean

The French Mediterranean has benefited from an organized investigation of its submerged cultural history, largely under the auspices of the Centre National de la Recherche Scientifique (CNRS). Many shipwrecks have been excavated and well documented, and their timbers have, in turn, been studied in attempts to understand their significance. Specialists from many disciplines have been included. Frédéric Guibal, a dendrochronologist, has incorporated ship timber into his attempts to build long chronologies as well as attempting to date them (Dramont E,⁷⁰ Culip VI,⁷¹ and the Port of Toulon⁷² are notable wrecks), including the first successfully-dated shipwreck in the western Mediterranean (Arles, 133 C.E.).⁷³ Guibal noticed early on that there was

⁶⁹ Flatman 2007, 62.

⁷⁰ Guibal 1995, 181-90.

⁷¹ Guibal 1998, 267-73.

⁷² Guibal and Serre-Bachet 1993.

⁷³ Guibal 1992.

potential for shipwrecks to contribute to chronology building, a basic practice in his field.

The French Mediterranean has been inhabited for millennia, which generally results in the consumption of old growth forests and prevention of long-term growth in new forests. Due to poor preservation and a long history of building with stone,⁷⁴ few good resources are available for chronology building on land. Shipwrecks, however, provide ideal sources and can usually be relatively dated to narrow their date range. Guibal acknowledges the common problems that 1) the shipyard where a vessel is built may not be known, and 2) even when the yard is known, timber can originate elsewhere. Despite these challenges, he has found some success (Fig. 2; notably, the Esterel and Jeaumegarde B wrecks crossdated with each other).⁷⁵ His work in tandem with Patrice Pomey significantly advances our understanding of ship timbers as artifacts.

Guibal and Pomey have worked together since at least 1996, when they consulted with Rival, to present the case for future analysis of shipwreck timbers from the region.⁷⁶ Since then, Guibal and Pomey have worked towards an understanding of how timber supply and naval architecture are related, under the project title "Dendrochronology and Dendromorphology of Ancient Mediterranean shipwrecks."⁷⁷ They acknowledge that timber should be analyzed for its many potential contributions and tend to ask statistics-based and anatomical questions.

⁷⁴ Guibal 1996, 505.

⁷⁵ Guibal 1996, 509-10.

⁷⁶ Guibal et al. 1996.

⁷⁷ Guibal and Pomey 2004, 2003, 2002, 1999, 1998a, 1998b.



Figure 2. French Mediterranean shipwreck chronologies.

Rectangles indicate fixed dates; ovals indicate floating dates (from Guibal 1996, fig. 5).

By comparing species and their use(s) within a hull for 27 wrecks, they found that species homogeneity tends to indicate high quality construction, whereas species heterogeneity tends to indicate a lesser standard of construction.⁷⁸ Based on a comparative analysis of hull planks and framing timbers they also deduced that as hull planks are more likely to be homogeneous than framing timbers, greater attention and effort was invested in the hull of the ships than the frames. As the authors acknowledge, this agrees quite well with the ancient "shell-first" shipbuilding tradition from the period under study (a theory championed by Pomey).⁷⁹ A practical response to these correlations is that it is easier to transport timber for hull planks by floating logs downriver than it is to transport the curved timbers necessary for framing members. Framing members, therefore, are more likely to come from local resources, which can quickly become depleted, and hull planks are likely to be imported over some distance, permitting choice cuts.⁸⁰ Unfortunately, Guibal and Pomey have not yet been able to source the shipyards or locations for almost all of the wrecks in their sample study.

Éric Rieth is another member of the French CNRS contingent who is particularly interested in ship construction trends. Though his research has spanned millennia, it is his focus on the Iberian Peninsula during the 15th and 16th centuries C.E. that is pertinent to this study. His work will be discussed in detail in the Iberian case study but merits note here. Rieth is especially familiar with early shipbuilding treatises and has studied the woods mentioned. His analysis and identification of the species used is a significant

 ⁷⁸ Guibal and Pomey 2003, 40-1.
⁷⁹ Pomey 1998, 49-72.

⁸⁰ Guibal and Pomev 2003, 41.

contribution, as this is not possible for many periods and cultures.⁸¹ His synthesis of the textual information yields an understanding that a concept of forest management existed in the selection of shipbuilding timber, though it is not clear if or what may have been enforced.⁸²

Central Mediterranean

Moving east in the Mediterranean, Ciciliot's cultural interpretation of ship timber, like Rieth's, focuses on documentation, but in this case Genoese contracts.⁸³ Primarily studying the Renaissance era, Ciciliot's contribution is an understanding of how timbers were secured, prepared, and transported to shipyards for skeleton-based hull construction.⁸⁴ Beginning in the middle of the 13th century, the Genoese trained timbers specifically for shipbuilding. *Garbo* or "moulded" timber was grown from oak stumps to encourage accelerated growth and it was artificially shaped to meet future curved timber needs in the shipyards (Fig. 3). Even with such advents, by the 16th century Genoa had to supplement its supplies from Corsica.⁸⁵ Albion⁸⁶ and Richard Barker⁸⁷ have also noted similar early methods of training timber elsewhere by propping saplings apart near their base and then tying the tops back together.⁸⁸ Training trees became more complex over time, likely in response to heavier demand for curved timbers in Europe. By the late 18th

⁸¹ See Meiggs' appendix on "The Confusion of Species" (1982, 410-422).

⁸² Rieth 1999, 33-40.

⁸³ Ciciliot 1993, 2002.

⁸⁴ He also discusses the possibility for diffusion of Genoese shipbuilding methods to the Iberian Peninsula (Ciciliot 2000a).

⁸⁵ Meiggs 1982, 384; Quaini 1968, 508-37.

⁸⁶ Albion 1926, 5-9.

⁸⁷ Barker 2000, 163-75.

⁸⁸ See Ciciliot 2002, figs 2, 4, 5.

and early 19th centuries, especially in France, the practice evolved to grow timbers of virtually any shape for a ship (Fig. 4).⁸⁹ These unnaturally-shaped timbers would require little working for their application in ships and should be obvious when recorded, especially if found in multiples. Like Lane's textual study of the Venetian timber supply, trained timber interpretations could be evaluated in comparison to an empirical study of ship timbers, but the lack of associated wrecks in the Genoese case hinders progress.⁹⁰



Figure 3. Examples of training live timber from an Italian manuscript dated 1754. A) Enlarging; B) Weighting; C) Crossing (after Ciciliot 2002, 264).

⁸⁹ See Ballu (2003, 69-85, 76-7) for a visual representation of the practice; see especially Goujon 1803.

⁹⁰ See Ciciliot 2000b, 13-35.



Figure 4. Timber for ships from early 19th century France (from Goujon 1803, pl.2).

Eastern Mediterranean

While the waters of the eastern Mediterranean have yielded several great finds, it is the same jagged coastline that may have contributed to the ship's demise that inhibits preservation of shipwrecked timber. Despite comparatively poor preservation of wood from shipwrecks in the eastern Mediterranean, the region has benefited from an intense history of archaeological investigation, specifically in the Aegean.

There is perhaps no better example of what can be learned from scant hull remains than the Late Bronze Age wreck found at Uluburun near Kas, Turkey.⁹¹ The importance of understanding site formation processes is elucidated in an investigation of the hull timber. Certain features that may be expected on timbers, such as tool marks, were "obliterated" by forces of nature over time.⁹² Attempts were made to identify the species used in construction⁹³ and to absolutely date the vessel.⁹⁴ Structural analyses of the remaining hull members have proven informative, such as the sailing implications of the shallow keel.⁹⁵ I have not been able to identify any other study of shipwrecked timbers, from any time or place, which so thoroughly accounts for site formation in understanding what can or cannot be learned from the timbers themselves. As evidenced at Uluburun, site formation is an important consideration when interpreting shipwrecked timbers.

⁹¹ See Pulak 1998.

⁹² Pulak 2002, 617-8.

⁹³An initial identification as fir (Abies sp.) was amended to cedar (Cedrus sp.) on further investigation

⁽Pulak 2002, 616). ⁹⁴ Much controversy has revolved around this issue (Pulak 1996, 12-3; Manning et al. 2001, 2532-5; Wiener 2003, 244-6; Manning et al. 2009, 164-87) and an absolute calendrical date for the ship's sinking is not yet available, despite a projected date of 1320±20 B.C.E. (Manning et al. 2009, 163).

⁹⁵ Pulak 2002, 619.
In a separate study, Pulak also offers a thorough analysis of the use of cedar (*Cedrus* sp.) for ships from an archaeological perspective.⁹⁶ He presents a practical reason for the preference of cedar, especially preceding the Iron Age. While durable in saltwater, cedar is comparatively soft and more easily worked with copper and bronze tools than other woods.⁹⁷ He also emphasizes the use of timber conversion studies⁹⁸ in understanding resource needs and offers a survey of ancient Mediterranean cedar-built ships.

A broader analysis of the use of cedar in the ancient Mediterranean is provided by Nili Liphschitz, but her study is geographically limited to the modern borders of Israel.⁹⁹ Liphschitz employs many varieties of archaeological material to reconstruct past climates, species distributions, and the timber economy (including *Cedrus libani*, *Juniperus phoenica*, *Pinus halepensis*, and *Cupressus sempervirens*), but only directly notes a single ship: the Uluburun wreck.¹⁰⁰ The challenges posed by dating the Uluburun shipwreck seem to have stalled other lines of timber investigation,¹⁰¹ except perhaps species identification and use relative to hull construction.

The study of the timber of the Greco-Roman wreck from Caesarea (dating ca. 440 B.C.E. to 40 C.E.) seems to typify the above trends.¹⁰² Predictably, radiocarbon dating and dendrochronology each fail to provide better resolution than relative dating or

⁹⁶ Pulak 2001.

⁹⁷ Pulak 2001, 24.

⁹⁸ Timber conversion studies are used to reconstruct the number and size of trees required to construct a single vessel, and usually require excellent preservation of a hull. See Chapter III for more details.
⁹⁹ Liphschitz 2007.

¹⁰⁰ Liphschitz 2007, 116-31, 164.

¹⁰¹ See Liphschitz's discussion of the dating of the shipwreck (2007, 164).

¹⁰² Fitzgerald 1994, 163-218.

provenance methods based on associated artifacts. A brief review of the tool marks from the timber is also offered. Fitzgerald presents a summary of the genus of nearly 50 wrecks, dating within a few centuries of the Caesarea ship. However, his analysis and conclusions are limited to the ultimate goal of placing the Caesarea ship within the traditions of eastern Mediterranean shipbuilding technology.

The analysis of the Ma'agan Mikhael ship (ca. 400 B.C.E.), however, expands the typical limits of eastern Mediterranean timber investigations. The authors state that their basic research questions are "the dating and location of the vessel's origin..."¹⁰³ but expand their work to cultural interpretations. In addition to the "standard" analysis typified by Fitzgerald's study, the researchers of the Ma'agan Michael ship address concepts such as timber selection, timber age clusters, quality control, and economy of timber use.¹⁰⁴ A perplexing observation was made: almost all of the planks in the hull were arranged by the direction of growth, relative to the direction of the ship. That is, the treetops were towards the bow and the root-end of the planks was oriented towards the stern.¹⁰⁵ Neither the authors nor I can think of a practical reason for this practice relative to either timber qualities or ship construction (nor any parallels), but it could not have been by chance. Attention to detail is evident from the earliest stages of preparation, as is a thorough knowledge of shipbuilding resources on the part of the builders. Perhaps the most important lesson learned from the Ma'agan Mikhael ship's analysis is that a well preserved hull has many opportunities for cultural interpretation.

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¹⁰³ Hillman and Liphschitz 2004, 145; see also Liphschitz 2004; Mor 2004.

¹⁰⁴ Hillman and Liphschitz 2004, 145-55.

¹⁰⁵ Hillman and Liphschitz 2004, 152.



Figure 5. Aegean Dendrochronology Project progress to date (from http://dendro.cornell.edu/images/charts/bargraph.jpg, accessed10 March 2010).

Since 1973, the dendrochronology laboratory at Cornell University has directed an effort to understand ancient timbers, specifically in the context of dating, and has regularly included ships and maritime sites. Though not directly related to the task of cultural interpretation of ship timber, the Aegean Dendrochronology Project may eventually provide the key for many avenues of investigation. The project was formerly directed by Peter Ian Kuniholm and is currently directed by Sturt Manning. Several gaps exist (Fig. 5), and it is likely that ship timbers will be critical to the bridging efforts. Other maritime sites are also included, such as harbors.



Figure 6. Yenikapı, Turkey. Exposed harbor works and tents covering ships (Author).

The harbor at Yenikapı (Istanbul, Turkey) is a good example of a related maritime site. As occupation and use at the harbor spans from the Neolithic through the modern day,¹⁰⁶ finds there are likely to prove of great importance in filling in chronological gaps. Thirty-three shipwrecks have been excavated at the harbor at the time of writing and more certainly remain, but harbor works, piers and other wooden remains have also been found. Results are pending,¹⁰⁷ but their study is very likely to include cultural implications for understanding ship timber (Fig. 6).

¹⁰⁶ Aytekın 2009, 28-37.
¹⁰⁷ See Kocabaş (2008) for a preliminary account of the works at the harbor.

Northern Europe

Outside of the Mediterranean, only one region has yielded as much research on ship timbers: the Baltic. The Baltic is an ideal candidate for interpretation of timber owing primarily to a beneficial preservation environment because until recently, the shipworm had not invaded the Baltic region,¹⁰⁸ and it has a long and rich history of ship finds.¹⁰⁹

The study of ship timber from the Baltic region has been superlative, but largely based in dendrochronology. Niels Bonde and Arne Emil Christensen provided a sterling early example of what can be learned from further dating and sourcing of ship timber in their interpretation of three Viking Age ship burials.¹¹⁰ Dating such vessels previously depended on relative techniques, such as the styles of carved wooden artifacts in associated grave goods. The growth and development of tree-ring dating since the 1970s in heavily treed northern Europe made subjective dating techniques such as the above, unnecessary.¹¹¹ In addition to providing independent archaeological dates via dendrochronology, Bonde and Christensen went further¹¹² to demonstrate the impact of economic systems on species distribution in northern Europe.¹¹³ Complicating their study, the ship's timbers failed to crossdate with local tree-rings chronologies. By geographically expanding their search through comparisons with other European

¹⁰⁸ Björdal et al. 2009.

¹⁰⁹ For example, the essentially complete Nydam boats (two discovered; one destroyed in 1864) were excavated between 1859 and 1863 (Crumlin-Pedersen and Rieck 1993). The Gokstad and Oseberg ship mounds were also excavated in the 19th century, in 1880 (Nicolaysen 1882) and 1867 (Bonde and Christensen 1993, 575), respectively.

¹¹⁰ Bonde and Christensen 1993.

¹¹¹ In many cases, tree-ring dating is "so precise that every recognized theory which conflicts with it is immediately discredited" (Bonde and Christensen 1993, 1982; Christensen 1982). ¹¹² Dean 1996.

¹¹³ Towner 2007, 2310.

species-specific chronologies, the source of some ship timbers was identified as Northern Ireland. Sourcing non-static objects, such as seafaring ships, in this manner is termed "dendroprovenancing."¹¹⁴ These approaches, complex and arduous at the time, are, or should be, relatively common practice now.

Similarly, the investigation of the ca. 11th century C.E. Skuldelev ships, led by Ole Crumlin-Pedersen, has demonstrated growth in the cultural interpretation of shipwrecks, rooted in dendrochronology. Even when ship timbers cannot be absolutely dated, as is the case for several of the Skuldelev vessels, comparison of the tree-ring data within a single ship can be revealing, especially about repair history and the lifetime of a vessel.¹¹⁵ The Skuldelev 1 wreck is an illustrative example. The vessel was likely built in 1025, but had significant repairs around 1043, 1059, and a third undated repair.¹¹⁶ Thirty-four years would seem not an insignificant life for a wooden ship, but how do we know if this is short, long, or an average lifespan for the time and place?

In addition to now standard radiocarbon and species identification (noted above), Crumlin-Pedersen's discussion of "wood technology" is informative.¹¹⁷ Most of the oak planks on the Skuldelev ships have radially-oriented cuts, whereas most of the pine planks are tangentially-oriented (Fig. 7). This and similar observations, such as the use of high quality wood employed in the ships, demonstrated that "considerable effort must

¹¹⁴ See Eckstein and Schweingruber 2009; Haneca et al. 2009, 7; Bonde 1997. Entire conferences now focus on this method, such as "Dendro–provenancing international meeting on historic timber trade and dendrochronology" held in Lithuania, 2005.

¹¹⁵ Crumlin-Pedersen 2002, 64-9.

¹¹⁶ Crumlin-Pedersen 2002, 65-6.

¹¹⁷ Crumlin-Pedersen 2002, 49-57.

have been invested by the boatbuilders in selecting trees of the right species, sizes,

shapes, and quality [for construction]."118



Figure 7. Wood splitting techniques from the Skuldelev ships (from Crumlin-Pedersen 2002, fig. 9).

Other practical lessons learned from study of the Skuldelev ships are found in admitted mistakes. A study of tool marks was undertaken decades after the ships were excavated, cleaned, and conserved with polyethylene glycol (PEG); only then was a loss of diagnostic information on timbers discovered.¹¹⁹ The tool-mark study then had to rely on the photographic records. Similar PEG-related problems were identified in the cross-

¹¹⁸ Crumlin-Pedersen 2002, 57. ¹¹⁹ Crumlin-Pedersen 2002, 57-8.

dating process.¹²⁰ As a result of the re-analysis and thorough record keeping it is presently preferred to record diagnostic information and secure samples for scientific analysis prior to conservation when possible.

Seán McGrail's contributions to the study of ship timber as a resource and reflection of culture are derived from those of Crumlin-Pedersen.¹²¹ McGrail's work is a necessarily brief survey of northern European timber studies through 1987, including most of his own attempts, and focuses on the structural merits and limitations of common species in ship construction. True to his roots, McGrail uses small-scale experiments to demonstrate principles. His examination of excavated wood remains includes early dendro-analysis, implications of timber shrinkage and swelling in construction and interpretation, and he reviews Crumlin-Pedersen's analysis of the Skuldelev ships. McGrail applies Crumlin-Pedersen's technique of identifying wood splitting techniques to other vessels and more recent technologies, confirming its usefulness. He provides a concise summary that is valuable for northern European investigations for those with little knowledge of wood structure and timber selection.

If Jan Bill's jargon-free review of medieval European ship construction is considered in concert with McGrail's technical analysis, a solid foundation for understanding ship timber of the period can be obtained.¹²² Bill considers big-picture questions about shipbuilding timber, and places the use of the primary building genera, oaks and pines, in context with basic ship construction methods and economic trends.¹²³

¹²⁰ Crumlin-Pedersen 2002, 66.

¹²¹ McGrail 1987; specifically the chapter titled "Trees and Wood."

¹²² Bill 1994, 151-9.

¹²³ Bill (1994) is especially useful for timber conversion and tool-kit analyses.

Much can be learned about local and regional economic systems when the dendrochronological data from a ship are extrapolated. Based on their Viking Age ship results Bonde and Christensen suggested the act of shipbuilding for the vessels under study was conducted in Scandinavia, likely Denmark, but the materials were shipped for the purpose across the North Sea, a daunting endeavor in the beginning of the second millennium. In a different study Towner clarifies that such an economic-procurement system required significant organizational and technological skills from a society.¹²⁴

Building on the work of Bonde, Christensen, and others, Aoife Daly's dissertation is now the seminal work for an analysis of ships and timber in the Baltic as cultural messengers.¹²⁵ The structure provides a "how-to" template for analyzing regional timber economies, and should be read by every maritime archaeologist. A dendrochronologist by training but familiar with ships, Daly has demonstrated significant progress in resolving one of the longest standing and critical issues that faces the nautical archaeologist, as explained by Lucien Basch in the first article of the first issue of the *International Journal of Nautical Archaeology*:

"The most important limitation [of nautical archaeology] is the virtual impossibility of deducing the shipyard where a vessel was built."¹²⁶

With an emphasis on provenance of shipwrecked timber, Daly combines living forest studies and chronologies with case studies of 22 ship finds. While each case study

¹²⁴ Towner 2007, 2311; 2002, 79-81.

¹²⁵ Daly 2007.

¹²⁶ Basch 1972, 50.

is useful individually, the primary contribution comes from her analysis of the timber economies in the region, rooted in the archaeological record. Especially important, she realizes that timber origin and the location ships were built are not necessarily the same.¹²⁷ By reworking extant data-sets to local-specific groups, the origin of the timber can be suggested to a small area.¹²⁸ When considered in context of historical analyses, an enhanced understanding of the local and regional shipbuilding traditions and resources emerges. The standard advanced by Daly is remarkable, but to date, impossible in any other region of the world. Northern Europe has benefited from great preservation of ship timber and decades of regional dendrochronology developments. Furthermore, Daly's relatively recent focus (since 1000 C.E.) permits the use of textual records not available for many other regions. Related studies by Tomaz Wazny,¹²⁹ George Indruszewski et al.¹³⁰ and Fred Hocker and Daly¹³¹ progress toward a cultural understating of ship timber in the Baltic.

Western Europe and the New World

The most thorough cultural interpretation of ship timbers is, without doubt, Loewen's treatment of the Basque wreck, 24M, found at Red Bay, Canada.¹³² In this study, Loewen managed to combine the archaeological, historical, and economic evidence about ship timbers to delve deep into a cultural understanding of the Basque

¹²⁷ Daly 2007, iv.

¹²⁸ Daly 2006.

¹²⁹ Wazny 1992, 2005.

¹³⁰ Indruszewski et al. 2006.

¹³¹ Hocker and Daly 2006.

¹³² See the entirety of Volume III of the *Underwater Archaeology of Red Bay* magnum opus, edited by Grenier, Bernier, and Stevens (2007).

system, in a manner that was unavailable to Albion, Lane, Meiggs, and others before. This is by no means his only work on this topic. He has also addressed the socioeconomic implications of resinous paying materials obtained from trees¹³³ and presented earlier endeavors in the direct relationship of forestry practices and hull design.¹³⁴ Loewen's analysis of the timber is integrated with discussions of forest economics, naval forestry, timber supply, hull design, and several other trades associated with building this vessel.¹³⁵

It is likely that an approach combining Rival's, Loewen's, and Daly's methods could completely resolve Basch's ship origin concern, noted above. However, the contemporary records in the form of timber and construction contracts that supported Loewen's interpretation, and the extensive localized chronologies that supported Daly's study are not available for most periods, nor do enough scholars have such an intimate understanding of shipbuilding as Rival. Regardless, much of what has been learned in each case can be gleaned from various empirical inspections.

In addition to individual efforts, several conferences and research groups have advanced our understanding of what can be learned from timbers as material culture, including: *Tree Rings, Environment and Humanity*,¹³⁶ the researchers of the Ma'agan Mikhael shipwreck,¹³⁷ and the works of the Groupe d'Histoire des Forêts Françaises.¹³⁸ Yet, even among the dozens of presentations included in the edited works above, few

¹³³ Loewen 2005.

¹³⁴ Loewen 1998, 2000; Loewen and Delhaye 2006.

¹³⁵ Loewen 1998, 2000, 2007a; 2007b; 2007c.

¹³⁶ Dean et al. 1996; see Guibal 1996, 508-11.

¹³⁷ Hillman and Liphschitz 2004; Liphschitz 2004; Mor 2004.

¹³⁸ Particularly, Corvol and Amat 1994, 1999.

authors directly addressed ships and seafaring. Where appropriate, they were incorporated into this review. Some volumes that would otherwise seem authoritative, such as *Bois et Archéologie*,¹³⁹ *Archaeological Wood*,¹⁴⁰ and *Man's Role in the Shaping of the Eastern Mediterranean Landscape*¹⁴¹ make virtually no mention of ships.

Replicas

Perhaps the most overlooked source of cultural information regarding ship timbers will come not from the artifacts themselves but from modern replicas and reconstructions. As the nature of shipbuilding is generally one of trade secrets, passed from master to apprentice, safeguarding their livelihood, much of the knowledge and practices involved in the building process are unrecorded. Until the 17th century C.E., shipbuilding treatises were exceedingly rare, and even then they were not exhaustive. Building replicas imposes many challenges, especially when contemporary methods and tools are employed. Despite many impressive replicas (for example: the *Kyrenia II, III*, and *Liberty*,¹⁴² *Olympias*,¹⁴³ *Min of the Desert*,¹⁴⁴ Skuldelev ships 1, 3, 5,¹⁴⁵ and the Hjortspring boat¹⁴⁶), little scholarly material has been published regarding how much timber was used in the process, difficulties or lessons learned in working it, or reflexive investigations of the archaeological material with the practical knowledge gained.

¹³⁹ Hackens et al. 1988.

¹⁴⁰ Rowell and Barbour 1990; Despite opening the volume with a recollection of the *Vasa* excavation, this volume sheds little insight into the cultural interpretation of ship timbers. It does, however dedicate a significant section to conservation of waterlogged wood.

¹⁴¹ Bottema et al. 1990.

¹⁴² Powell 2002; for further information on Kyrenia ship replicas see http://www.kyreniaship.org.

¹⁴³ Morrison et al. 2000.

¹⁴⁴ Ward et al. 2008.

¹⁴⁵ Many replicas, see Crumlin-Pedersen (forthcoming).

¹⁴⁶ Many replicas, for one example see Valbjørn et al. (2003) and Valbjørn (2003).

A notable exception to the above and the archetypal academic study of ship reconstructions is that of the *Olympias*. The *Olympias* is an approximation of an ancient Greek warship, ca. 5th century B.C.E., which drew heavily on archaeological and historical references. Though no Greek warships themselves have been recovered, shipsheds,¹⁴⁷ rams,¹⁴⁸ and other archaeological discoveries permitted a reasonable basis for reconstruction of a trireme. Considerable attention is given to the historical documents, in light of the archaeological evidence. In a chapter titled "The Materials,"¹⁴⁹ John Morrison provides a condensed explanation of the woods from which a trireme *should* be built, but due to the practical constraints of obtaining such timbers in the volume or dimensions required for this ship (they no longer exist), opted for other species with similar properties.¹⁵⁰ This seems to be a common trend and justification among ship reconstructions.¹⁵¹

The *Olympias* project is especially progressive in its reanalysis of the ship, ancient technologies, and what such efforts can be expected to yield. *The Trireme Project: Lessons Learnt*¹⁵² is characteristic of the reflexive investigations resulting from the planning, construction, and operation of the ship. Unfortunately, I am not aware of any of these investigations which focus on the timber itself. Even projects which present the highest standard of rigor have overlooked such basic questions as "how many trees were needed to build this vessel?" McGrail, the foremost advocate for and a widely

¹⁴⁷ See Blackman 1987, 1996, 2003.

¹⁴⁸ See Casson and Steffy 1991; Oron 2006.

¹⁴⁹ Morrison et al. 2000, 179-90.

¹⁵⁰ Morrison and Coates 1989, 20.

¹⁵¹ For other examples see McGrail 1987, 23-6; Crumlin-Pedersen 1996, 113; Ward et al. 2008, 127.

¹⁵² Shaw 1993.

recognized expert on experimental nautical archaeology, lends considerable credibility to the research efforts of this project, stating:

"The data, the methods, the arguments and the conclusions are there for all to see and to criticize... [which] is not the case with most other replica projects... In my opinion this project has been a valid archaeological experiment: a model for others to follow."¹⁵³

McGrail regularly re-evaluates the status of collective ship reconstruction efforts,¹⁵⁴ but in his extensive work with reconstructions he rarely addresses the materials themselves. This is endemic with "first-generation" nautical archaeologists, as their early focus of the field was heavily focused towards understanding construction technology and trends. Yet, with his team's work on the Hasholme logboat (ca. 300 B.C.E.) they intended to "extract as much information as possible about all the timbers" including "size and age of tree used or type of woodland [where it grew]."¹⁵⁵ For the time, these were advanced concepts in timber studies. Despite not meeting with extraordinary success in the stated goals, his well formed, tested, and reported research questions permit any reader to learn from the unsuccessful examinations, which influenced his own subsequent studies.¹⁵⁶ This study advanced the understanding of what may be learned from technologically less complex craft.¹⁵⁷

¹⁵³ McGrail 1993, 4.

¹⁵⁴ McGrail 1977, 1997, 2006.

¹⁵⁵ Millett and McGrail 1987, 79.

¹⁵⁶ For example, on the "Dublin Timbers" (McGrail 1997, 239-55).

¹⁵⁷ See also his chapter regarding "Aspects of Wood Science" (McGrail 1997, 149-56).

Summary

A survey of the ship-timber-interpretation literature reveals that most studies are strictly historical or archaeological, relative to the researchers' training. Historical studies are typically compilations of texts (tax records, timber contracts, botanical observations, etc.) joined by a synthesis. Archaeological studies usually involve attempts to date or source the wood and a technological analysis of hull construction. Given how much time is required to work with timbers for a technological analysis of hull construction, it is surprising that so few people have taken notice of the timbers themselves as individual artifacts, not just as pieces of a puzzle. There seems to be an epidemic of overlooking the forest for the trees. By restricting analysis to only one field of evidence or one basic result,¹⁵⁸ too many details about the most important material of every pre-Industrial wooden vessel have been overlooked. However, several scholars have made major advancements and expanded our understanding of timbers as items of material culture and indicators of human-environment interaction. A summary of these methods is presented in the following chapter.

¹⁵⁸ For example, understanding a hull's place in the "evolution of shipbuilding" or dating and sourcing.

CHAPTER III

METHODS OF ANALYSIS

This chapter provides a series of analytical questions and tests that can be performed on a collection of ship timbers and assesses them to clarify what can or cannot be gained from such analyses. Several resources exist to aid in a cultural study of ship timber beyond the visually observable material record, including chemical analyses, the written record, iconography, and in some cases ethnographic studies. Most of these will be considered in context of case studies presented in the following chapters.

In any thorough analysis of timbers, it is important to include varied resources. Treatises on shipbuilding, for example, often neglect many of the practical aspects of the art that the material record can help reveal. Many of the day-to-day methods used by shipbuilders would have been considered common knowledge and may have gone unrecorded for a variety of reasons. Much of the practice was possibly considered trade secrets, passed from master to apprentice, but evidence of these methods remains in the shape, placement, and character of the timbers themselves.

Two basic categories for the derivation of behavioral and cultural information from ship timbers can be identified: common and uncommon methods of analysis.¹⁵⁹ Each category is discussed below. Emerging methods are included in a separate category, as the methods, expectations, and limitations are not yet refined.

¹⁵⁹Modified and based on Dean (1996, 463).

To date, empirical investigation of the wood itself has proved to be the most useful method for a cultural understanding of ship timber. Perhaps the simplest and most obvious approach, the extent of its potential is nevertheless often overlooked. Such analyses are tied into larger methodological approaches, such as dendrochronology. In practice, "empirical analysis" of ship timber tends to be limited to inference regarding the following:

1) tool marks and reconstructing tool kits;

2) assembly and construction marks;

3) timber size and shape;

4) species identification and use.

In addition, such analysis should also include, at a minimum:

5) relative timber ages;

6) age clusters;

7) reuse;

8) timber conversion studies;

9) basic wood anatomy.

Common Methods

Tool Marks and Reconstructing Tool Kits

With comparative data derived from contemporary tools and the marks they

leave in timber, observing tool marks on wood from archaeological sites and

reconstructing tool kits from them has long been practiced in nautical archaeology.¹⁶⁰ Little specialized knowledge of shipbuilding or timber is required for this exercise. A basic historical understanding of the technologies available around the time the ship was built provides an adequate base from which to begin such analysis.

A trained eye can distinguish the differences between manually- or mechanically-powered woodworking tools, such as adzes, axes, augers, chisels, gouges, planes, and saws.¹⁶¹ With minimal experimentation, even a novice stands a reasonable chance to correctly identify these marks. Occasionally, a shipwreck even includes a tool kit against which to compare.¹⁶² Most of these tools have been in use for at least 4,000 years,¹⁶³ with few significant adaptations, at least insofar as the marks they leave.

A superlative example of the interpretation of tool marks is Hadas Mor's work on the Ma'agan Mikhael ship (late 5th century B.C.E.).¹⁶⁴ At least nine tool types were identified, with several in a variety of sizes. Mor's work is well illustrated and describes the use of the tool and how each tool's marks can be recognized. Fortunately, a carpenter's kit was also found in association with the ship,¹⁶⁵ making essentially a direct comparison of tools and timber marks possible. Three distinct units of measure have been identified on the tools.¹⁶⁶ Mor compares the tools marks to contemporary vessels,

¹⁶⁰ Numerous vessels have provided such information, for example ancient Egyptian watercraft (Ward 2000, 23-8), and the Uluburun ship (Pulak 2002, 629-31).

¹⁶¹ See Blackburn (1974) and Goodman (1976) for aids in identifying various tool marks and basic histories of woodworking tools.

¹⁶² Notable examples include the *Mary Rose* (McKewan 2005, 293-319) and the 7th century C.E. wreck at Dor, Israel (Galili et al. 2007, 24 July, "Dor, The Southern Anchorage" http://www.hadashot-esi.org.il/report detail eng.asp?id=562&mag_id=112).

¹⁶³ See Killen 1994, 12-25.

¹⁶⁴ Mor 2004, 165-81.

¹⁶⁵ Udell 1990.

¹⁶⁶ Pheidonian, Solonian, and Italic (Stieglitz 2006, 195-203).

iconographic evidence, and historical evidence. Perhaps most useful is the brief "Discussion and Conclusions"¹⁶⁷ section, which states challenges encountered and how they were resolved.

It should be noted that several factors can impair the ability to interpret tool marks or reconstruct a tool kit. Poor preservation and conservation are the two factors most likely to limit analysis. Either can completely obscure or delete information that might have been present, as was demonstrated by investigations of the Skuldelev and Uluburun ships.¹⁶⁸ Ships excavated and conserved during the first generation of nautical archaeology are more susceptible to this problem, due not to lack of expertise but to lack of experience. Subsequent generations have, or should have, learned from their experiences. Excellent original craftsmanship can also hinder analysis by smoothing the faces of the timbers, but it is rare that shipbuilders invest the time and energy to provide such a finish,¹⁶⁹ especially in the lower portions of a hull that tend to survive.

Assembly and Construction Marks

Absent written records or other historical documentation, it is difficult to envision what might differentiate "construction" marks from "assembly" marks other than the context in which a vessel is found, so they are considered here together. When it is possible to distinguish between the two, the reason(s) is noted below. If it is not possible, the term "construction" is employed as a generalization.

¹⁶⁷ Mor 2004, 180.

¹⁶⁸ Crumlin-Pedersen 2002, 57-8; see also the preceding chapter in this dissertation.

¹⁶⁹ For example, of the Ma'agan Mikhael ship's timbers Mor stated "The final timber surface is the result of one or more processing stages, not all of which left visible traces" (2004, 165).

The constraints and concerns observed regarding tool marks similarly apply to the interpretation of assembly and construction marks, especially in terms of preservation and conservation. Assembly and construction marks appear to be uncommon or are frequently overlooked due to their subtle nature. Such markings can be painted on the timbers, incised, or both. Typically these marks can be used to deduce the method in which a ship was built (that is, shell- or skeleton-based¹⁷⁰), which has implications for the kinds and cuts of timber employed. In shell-based construction, internal framing members are usually less important to the vessel's integrity or are at least viewed as such by the builders. This may lead to lower-quality timbers being used for frames. In skeleton-based construction, the planking is generally viewed as a watertight skin and not as a structural component. This too is reflected in timber choice. It is also likely in some cases that construction method is affected by timber availability.

Prominent examples of painted construction marks are found on the Marsala Punic ship¹⁷¹ and painted assembly marks appear on Khufu I vessel from ancient Egypt (26th century B.C.E.) (Fig. 8).¹⁷² On the Marsala Punic ship, built in the shell-first tradition, the location of frames and joints were indicated by letters of the Punic alphabet painted on the hull planks.¹⁷³ Incised marks, similar to those found on the Ma'agan

¹⁷⁰ For clarification on "shell" and "skeleton" construction, see Pomey (2004, 25-36).

¹⁷¹ Letters in black calligraphy are reported to have showed very clearly in contrast to the pine planking; Johnstone 1976, 191-239; Frost 1976.

¹⁷² These are termed assembly marks for Khufu I vessel because it was found disarticulated in a pit for the pharaoh's use in the afterlife, which would require it to be reassembled; in addition to paired symbols used to match individual timbers, four hieratic symbols were used to indicate general locations of timbers in the reconstruction: port-forward, port-aft, starboard-forward, or starboard-aft (see Jenkins 1980, figs 62, 63). ¹⁷³ Johnstone 1976, 198-219.

Mikhael wreck,¹⁷⁴ were also present on the Punic ship, probably to locate frames. Such marks, often termed "scriber marks," can also be found on the Kyrenia ship (ca. 290 B.C.E.).¹⁷⁵



Figure 8. Assembly marks on the interior faces of timbers from the Khufu I vessel (from the Paul Lipke Collection. Photograph by Sherri Moore).

¹⁷⁴ Mor 2004, 174-5 ¹⁷⁵ Steffy 1994, 43: a scriber is a sharp blade used to superficially mark timbers.

Prominent incised construction marks are found on the Jules-Verne vessels number 7 and 9 (likely Greek, ca. 6th century B.C.E.),¹⁷⁶ and assembly marks are found on the French ship *La Belle* (wrecked in 1686 C.E. off the shore of present-day Texas).¹⁷⁷ Loewen's interpretation of timber markings in the 24M Basque ship should also be noted as an exceptionally thorough analysis.¹⁷⁸ In the Jules-Verne 9 wreck, a fishing boat built in the sewn tradition, a pattern of three lines were regularly incised to indicate the locations for sewing holes, to ensure proper spacing.¹⁷⁹ In the Jules-Verne 7 wreck, likely a merchant ship also built in the shell-first tradition, chevrons were incised in the hull planks to indicate the locations of internal framing members (Fig. 9).¹⁸⁰



Figure 9. Incised chevron on the Jules-Verne 7 shipwreck timbers (from Mor 2004, fig. 21. Photograph by G. Reveillac, Centre Camille Jullian, France).

¹⁷⁶ Pomey 2001, 425-37

¹⁷⁷ Bruseth and Turner 2004, 76-81; Grieco 2003; Carrell 2003, 197-201.

¹⁷⁸ Loewen 2007a, 2007b, 2007c; The analysis is dispersed over several hundred pages.

¹⁷⁹ Pomey 2001, 425-7; Mor 2004, 173-4.

¹⁸⁰ Pomey 2001, 429.

La Belle, at 40 to 45 tons was a comparatively small ship for the period, was built as a prefabricated vessel, philosophically similar to inexpensive assemble-at-home furniture kits available today. Historical documents indicate that Robert de La Salle intended to load the disarticulated pieces into another vessel, ferry it to New France and reassemble it for use.¹⁸¹ This did not occur because La Belle was assembled in France and made the Atlantic voyage, but the ship having been built for the purpose necessitated assembly instruction, and what better way to preserve the instructions than inscribing them directly onto the timbers? During conservation of the hull, numerous assembly marks were discovered on La Belle's frames.¹⁸² Marks on every third frame marked the positions of the ribbands that were used to define the hull shape. The frames in between were cut using the same moulds but positioned after the ribbands were in place. These filler timbers could be selected from a reserve to fit the space accordingly, and, if managed well, could result in less wasted timber. If the shipwright cannot venture into the forest, then they must have a method to provide the woodcutters with moulds and other predictable measurements.¹⁸³ Such predictability or regularity should, somehow, be visible in or on the timbers, either by markings or perhaps by age, size, and shape.

Timber Size and Shape

Comparing the size and shape of timbers used in a ship's hull to historical interpretations of available raw materials (that is, maximal or common dimensions of a

¹⁸¹ Bruseth and Turner 2004, 73.

¹⁸² Bruseth and Turner 2004, 76; see also Carrell 2003.

¹⁸³ Ciciliot 2002, 256-7.

tree species in the forest) is not uncommon, but what it reveals is often difficult to interpret. Several factors can have an impact on the ability of a society or individual shipbuilder to procure choice timbers, including: economics, geography, and political relationships. Also relevant may be the fact that the best trees may have been harvested regularly and continually from most forests, depleting the gene pool and changing timber sizes and shapes over time. Fires and the pollinating strategies of different related species may also have changed the shape and size of trees over time in a given region, as selecting for different uses. The cork oaks Fernando Oliveira saw around Lisbon in the 16th century were planted for shipbuilding and charcoal production and were probably rather different than the ones we see today, selected for cork extraction.¹⁸⁴ Even if the most ideal timbers are obtained, the technology available to the builder may not permit use of the timber in an ideal manner. Preferences and even tastes in ship construction can be unrelated to materials or ship technology and may affect the way a timber is cut.¹⁸⁵ When analyzing ship timbers, it is important to eliminate extenuating factors, or at least account for them, before drawing conclusions based on how large a certain species is known to grow and the size or shape of such timbers used in a hull. Joggling,¹⁸⁶ top-andbutt joinery,¹⁸⁷ and similar methods of fitting timbers (like pieces in a puzzle) are sometimes interpreted as responses to raw material limitations,¹⁸⁸ but these are in many

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¹⁸⁴ Barker 2000, 163-75.

¹⁸⁵ For example, the ancient Egyptians' apparent need to transport boats long distances overland necessitated that timbers be of a manageable size when disarticulated, despite having technologies and resources that would have permitted the use of much larger timbers (see Creasman and Doyle 2010). ¹⁸⁶ Steffy 1994, 273, fig. 3–3.

¹⁸⁷ Steffy 1994, 291.

¹⁸⁸ For example, Castro 2005, 129-42.

cases just technological responses to redistribute stress in a hull.¹⁸⁹ Factors beyond the timber itself must be considered in order to draw the correct conclusion. When a key structural member is comprised of numerous timbers, such as a keel or main mast, there is little support for the suggestion that this practice is of structural benefit, and it probably directly relates to timber supply problems, repair, or frugality. Detailed analysis of this method is provided in subsequent chapters, especially in regards to the ancient Egyptian Dahshur boats (ca. 1850 B.C.E.) and the Portuguese Indiaman *Nossa Senhora dos Mártires* (known as the Pepper Wreck, foundered in 1606 C.E.).

Loewen's analysis of timber size and shape is eminently useful but greatly overlooked. He has developed a solid method, tested it on at least two ships,¹⁹⁰ and derived much information about cultural practices and behaviors. Evaluating the correspondence between a tree's original shape and that of the finished timber can occur in the curvature and diameter versus squared dimensions.¹⁹¹ To compare the curvature, one traces the center and rings of the wood grain at both ends of an individual timber; if the patterns correspond, it is likely the tree from which the finished timber came had a shape close to that of the final product. If this is more often the case than not in a hull, it is a reasonable assumption that quality raw materials were available, as curved timbers have in all ages proven to be the most difficult to obtain. After incorporating historical and economic data, the reason timber was available (i.e. naturally, via trade, war prize, tribute, etc.) can be understood.

¹⁸⁹ Ward 2000, 48-9; Creasman forthcoming.

¹⁹⁰ The Cavalaire-sur-Mer wreck found in France, ca. 1470 C.E. (Loewen 2000) and the Red Bay 24M hull (Loewen 2007a, 2007b, 2007c).

¹⁹¹ Loewen and Delhaye 2006, 102; the following explanations are also directed from this source.



Figure 10. A waney edge (Author).

Comparing the diameter of the raw resource to the squared dimensions of the finished timber is similarly revealing. High correspondence, which is finished timbers that are close to their grown diameter, would seem to indicate either that waste was kept to a minimum or that the harvester had anticipated the needs of the carpenter.¹⁹² The identification of "waney edges" on oaks (a characteristic not present or prominent in other genera) can help to identify the natural outermost layer of the timber and thus indicate correspondence between original diameter and finished diameter (Fig. 10),¹⁹³ as

¹⁹² Loewen 2000, 146.
¹⁹³ Loewen 2007a, 270-1; 2000.

can bark, beetle galleries, a shiny patina, or a continuous ring around a sample on most species.¹⁹⁴

Conversely, timber size and shape may indicate a lack of resources, especially if curved timbers are split longitudinally.¹⁹⁵ Framing timbers supplied from split raw wood probably indicate limited timber resources, as an intact timber is stronger and preferable. Splitting is practical because it can yield mirror-image pieces for use on port and starboard sides when supplies do not otherwise meet demand. Split timbers can be identified by examination of their wood grain in section. If split timbers are found, as in the case of the central floor timbers of the 9th century Bozburun shipwreck,¹⁹⁶ these can, and should, be compared to timbers on the opposing side of a ship (if available).

Species Identification and Use

Few, if any, ship excavations forgo basic species analysis of the timber. Species analysis is typically a prerequisite for successful dendrochronological dating (discussed below). Dating and sourcing the species appear to be the most common reasons for identifying wood types. However, the comparison of genera or species employed in a ship to the known species of suspected home port for ships can also aid an understanding of the shipbuilding industry on local environments,¹⁹⁷ reconstructing timber trade,¹⁹⁸

¹⁹⁴ Towner 2007, 2309; Towner 1997; Ahlstrom 1985.

¹⁹⁵ Loewen and Delhaye 2006, 102-3; Loewen 2000.

¹⁹⁶ Harpster 2005, 416-25.

¹⁹⁷ See Douglass (1935) for an example of employing archaeological wood in assessing human impact on the environment and Dean (1969) for identifying local environmental change, though neither addresses ships.

¹⁹⁸ See Wazny (2005) for a related example.

quality of construction,¹⁹⁹ and even construction philosophy.²⁰⁰ Comparing species and their use *within* a hull can yield "signatures" that assist in sourcing ships (i.e. oak for framing and pine for hull planking)²⁰¹ or identify repairs.²⁰²

Radiocarbon Dating $({}^{l4}C)$

Radiocarbon dating should be noted here, albeit briefly.²⁰³ The method provides approximate dates for the death of an organism, based on the radioactive decay of the carbon-14 isotope, which has a half-life of 5,730 years. Intuitively, ¹⁴C dating *should* be a more useful tool for the interpretation of ship timber, especially burned timbers, but its cost seems to have stifled creative and expansive applications other than spot-dating. Analysis of a single sample currently costs between \$450 and \$850, depending on the laboratory, volume, negotiations, and other factors between the submitter and testing laboratory.²⁰⁴ It is conceivable that radiocarbon dating each timber in a hull may yield interesting results, especially about the lifetime of a ship, and age sets for timbers (where dendrochronology is not available, conclusive, or possible). However, I am aware of no

¹⁹⁹ As noted in the previous chapter, species homogeneity tends to indicate higher quality of construction while heterogeneity indicates the opposite (Guibal and Pomey 2003, 40-1).

²⁰⁰ Also as noted in the previous chapter, species homogeneity for one category of ship timber, such as hull planks, and a lack of homogeneity for other structural components, such as frames, may indicate construction philosophy, in this case shell-first (Guibal and Pomey 2003, 40-1).

²⁰¹ See Loewen 1998, 47-8; this could also contribute to typologies, such as the Iberian-Atlantic features proposed by Thomas Oertling (1989a, 2001, 2004).

²⁰² The Skuldelev ships are a prominent example (Crumlin-Pedersen 2002, 56, 64-8).

²⁰³ For a summary of the current status and challenges of archaeological radiocarbon dating, see Ramsey et al. (2006, 783-98).

²⁰⁴ At some government subsidized laboratories a single sample can run as low as \$50, but the results may not be available for years. Also, projects sponsored by the National Science Foundation (NSF) may be able to have specimens processed at no cost, but again this typically involves a lengthy wait for results. It is expected that such subsidies will be terminated in the near future and thus prices will more accurately reflect those stated in the text. Finally, as comparatively few shipwreck excavations receive NSF funding, these figures provided are those most likely to apply to the majority of projects.

examples where this method has been employed with such vigor. For a small vessel, for example a 10 m Dahshur boat (ca. 1850 B.C.E), such an endeavor would cost up to \$75,000 (150 timbers, one sample each, at \$550 per sample²⁰⁵). The practice of taking two samples per timbers, 25 to 50 rings apart, has improved the reliability of results, but would double this value. Despite the cost, ¹⁴C dating has proved indirectly useful to timber analysis, especially in the case of derelict or other vessels recovered without diagnostic artifacts. If a ship cannot be relatively dated by its artifact assemblage, ¹⁴C dating can typically narrow down the range of uncertainty to within \pm 100 years.²⁰⁶

Dendrochronology

Tree-rings are especially valuable for yielding absolute, single-year (and often seasonal resolution) dates for past events and processes.²⁰⁷ No other geochronologic or archaeometric method of dating offers this level of resolution or reliability. Like nautical archaeology, the field has advanced rapidly in recent years.²⁰⁸ Over the past half century, dendrochronology has embraced the use of various new tools and techniques, including isotopic and chemical analyses and various methods of measuring wood density and micro-anatomy. Tree-rings are subject to archaeological, biological, climatological, ecological, and geological applications, each spawning several subfields (e.g. dendroclimatology, dendrohydrology, dendrochemistry, etc.). Its investigations are no

²⁰⁵ \$550 is a conservative estimate probably available only for academic bulk rates.

²⁰⁶ See Booth (1984) for a list of 185 maritime sites that have been radiocarbon dated. At the time, this list was likely exhaustive, or nearly so, but to compile one today would be virtually impossible as it is exceptionally common.

²⁰⁷ For an introduction to tree-ring dating methods and theory, see Stokes and Smiley (1968).

²⁰⁸ See Eckstein and Schweingruber 2009, 7-13.

longer limited to providing date, species, and location, although these remain its most common archaeological applications.²⁰⁹ The widespread assumption that this is all of the information that can be derived from dendrochronology is probably the greatest impediment for the application of dendroarchaeology to shipwrecks. Tree rings are natural chronometers and recorders of change in the environment with which other biological research is inescapably linked, and their study can reveal much about human/environment interactions.

The original contribution of dendrochronology was discovery of the exact calendrical dates for the construction and abandonment of ancient cliff dwellings and other ruins of the American Southwest.²¹⁰ This contribution, the dating of archaeological remains is now generally termed "dendroarchaeology," and is discussed below. The study of archaeological wood-use behaviors and extrapolation of other general cultural knowledge from wood is a relatively recent advent in tree-ring analysis, usually credited to Jeffrey S. Dean, in 1996.²¹¹

There are three primary compounding factors when seeking useable samples for dendroarchaeological investigation of ships:²¹²

1) Preservation: there must be enough wood available for analysis. In some cases, an entire timber (or most of one) is used as a sample. Unlike most ancient wrecks, historic wrecks typically present large amounts of timber, allowing for development of

²⁰⁹ Stokes and Smiley 1968; Fritts and Swetnam 1989; Dean 1996.

²¹⁰ Douglass 1929, 1935.

²¹¹ Nash 2002, 254.

²¹² After Dean 1996; such investigations can also include cargo, i.e. the Commachio wreck (Kuniholm 1992, 30 January), anchors (see Hadas et al. 2005), and other wooden artifacts of a nautical nature.

good sampling theory and for procurement of extra samples. With most wrecks, sampling is dictated by what remains.

2) Modification: the timbers have been worked to fit their purpose and possibly worked several times prior. Virtually all wood in a ship is a potential source for the derivation of cultural information. However, sampling can be targeted for desired research questions. For example, framing and other curved timbers tend to more closely follow the natural growth of the trees from which they came than many other timbers (i.e. hull planks); they also tend to have the greatest number of remaining rings and are best for dating and chronology building. While hull planks, as noted above in "Timber Conversion Studies," are often heavily worked, they can provide evidence of wood technology, timber selection, quality control, and economy of timber use.

3) Recovery: archaeologists compete with treasure hunters, who, in the course of their quest for commodities, typically destroy hull remains which lack market value.

Uncommon Methods

Dendroarchaeology and Nautical Archaeology

Despite that dendroarchaeology and nautical archaeology have had a longstanding recognized potential,²¹³ currently the relationship is one more of opportunity than practice.²¹⁴ Little progress has been made to address the basic concerns

²¹³ As described in Farrell and Baillie's article (1976) titled "The Use of Dendrochronology in Nautical Archaeology."

²¹⁴ Most "state of the discipline" or "future of the field" review articles by respected scholars in the field either neglect shipwrecks (Baillie 2002; Sass-Klaassen 2002), note them in passing (Kuniholm 2001b; Nash 2002), or indicate they are still a source of potential (Čufar 2007; Haneca et al. 2009). In all cases the situation is clear: the relationship is one more of opportunity than practice.

noted by Farrell and Baillie.²¹⁵ In only three times and places worldwide do the disciplines intersect with regularity: Northern Europe and Scandinavia over approximately the last 1,000 years,²¹⁶ the French Mediterranean region,²¹⁷ and the eastern Mediterranean.²¹⁸ With rare exception, the rest of the seafaring world has yet to see substantial benefit from a merger of these fields. All three basic dendroarchaeological lines of investigation (chronological, environmental, and behavioral²¹⁹) have potential to contribute to the study of ship timber.

Although dendroarchaeological studies are not uncommon in the investigation of ancient, medieval, and Old World wrecks, historical and New World shipwreck studies rarely (never?) include dendrochronology.²²⁰ This is counterintuitive. Wooden archaeological remains, including shipwrecks, and sufficient parallels from which to build a reliable chronology are far more abundant for the historical period. Tree-ring data and chronologies associated with the historical period are thus more complete or often easily compiled.

Dendrochronology provides only a felling date for the tree, namely, the year the tree died, which is not necessarily when it was employed in construction.²²¹ This supposed problem can be a boon to understanding timber-use patterns, such as seasoning and stockpiling. If a shipwreck, associated artifacts, contemporary records, or some other

²¹⁵ Farrell and Baillie 1976, 45-55.

²¹⁶ See Daly 2007, 2006.

²¹⁷ See Guibal 1996; Guibal and Pomey 2004, 1998b; Guibal and Serre-Bachet 1993.

²¹⁸ See Manning et al. 2009; Liphschitz 2007; Kuniholm 2002; Manning et al. 2001.

²¹⁹ From Dean 1996.

²²⁰ I am aware of no successful dendroarchaeologically dated/investigated ships built and found in the New World. Several unpublished attempts have been made, but none have met with success.

²²¹ Towner 2007, 2307-15.

source (such as a mast-step coin²²²), provide a launch or build date with confidence, but this date does not match the dendrochronological date for felling of the timber, some other process must be in action. This could be stockpiling, reuse, use of deadwood, or the result of seasoning timber. Further investigation of contemporary records and practices may be able to reveal the extenuating factor(s). Regardless, the wood will indicate that some cultural phenomenon has occurred.

Vessels that have been intentionally sunk to provide a base for a wharf, pier, harbor works, or in the case of the Skuldelev hulls, to limit the size of ships that can berth in a harbor, are prime candidates for dendroarchaeological investigation. In such cases, when a watercraft has been stripped for abandonment, it is the timbers themselves that can provide evidence of a date, as construction trends can only provide an estimate.

Use of data drawn from ship timbers will facilitate the growth of and bridging between chronologies, particularly in regions that have long been densely populated, where living trees and terrestrial resources are regularly reused.

Historic ships hold great promise for dendrochronology, and vice versa. An historic shipwreck might be dated with a high degree of confidence because of an insurance claim, for example. Wood from the hull could subsequently be used to extend climate data or bridge a chronological gap. There are distinct needs for such data. It has, for example, been difficult to extend teak (*Tectona* sp.) chronologies because the wood has been valued for so long for architectural and ornamental purposes that reuse has

²²² See Carlson 2007, especially 319.

considerably complicated the establishment of a dating sequence.²²³ One relatively dated shipwreck constructed of Indian teak, perhaps from the era of Portuguese Discoveries, could double the length of the current chronology. Even a small boat of under 10 meters can yield a chronology spanning 300 to 500 years or more, depending on the species.²²⁴ The possibilities contained in a large vessel with a long working life and several repairs are, of course, correspondingly vaster.

Timbers can also reveal origin, a subfield known as "dendroprovenancing."²²⁵ The Skuldelev 2 vessel, a Viking-era longship discovered off the coast of Denmark, was built of wood from Dublin, Ireland.²²⁶ This revelation of not only date but also of economics and environment was made possible by the use of that most basic dendrochronological technique, the comparison of tree-ring data.

Daly has laudably used the growing network of chronologies (specifically for oaks) in Northern Europe to begin localizing source information and ship provenance. Her work, although limited to that region since about 1000 C.E.,²²⁷ demonstrates that it is only by growing chronologies at local levels that archaeologists will be able to narrowly source individual ships with confidence, thus progressing toward a resolution of Basch's concerns (see previous chapter) regarding the elusiveness of ship origins.²²⁸

²²³ See Devall and Parresol 2003.
²²⁴ Kuniholm 1992, 30 January.

²²⁵ The best examples include Daly (2008, 2007); for background on the subfield see Sass-Klaassen (2002) and Haneca et al. (2009, 6-7).

²²⁶ Crumlin-Pedersen 2002, 67.

²²⁷ Daly 2007, 2006.

²²⁸ Basch 1972, 50.

Relative Timber Ages

Through the use of dendrochronology, comparing relative timber age between components in a hull can indicate repairs and the lifetime of a vessel, or patterns of reuse. The Skuldelev 1 ship, discussed in the previous chapter, is an illustrative example.²²⁹ Another example is the *terminus ante quem* provided by the dendrochronological dating of a repair ceiling plank on the Cavalaire-sur-Mer shipwreck.²³⁰ If paired with a dendrochronological *terminus post quem*, a minimum lifetime could be estimated. Performing similar analyses successfully for many ships from a similar period would allow for the deduction of a mean lifespan for vessels. The cultural implications of such information could be great. Are societies willing to invest the resources to build multiple ships that have relatively short lives, perhaps of only a few years (for example, ships on the *Carreira da Índia*, or "India Run"²³¹)?

Complications with such an analysis come in the need for an established chronology for the time, place, and relevant species. Even equipped with such data, less than 35 percent of *all* archaeological dendrochronology specimens date,²³² and for ships the figure is much lower.²³³ It should be noted that a ship could remain in use for many years after such a repair, but it is unlikely that a repair would occur after a vessel ceased to be useful. The nature of archaeological preservation may also complicate analysis,

²²⁹ Crumlin-Pedersen 2002, 65-6.

²³⁰ Loewen 2000, 147.

²³¹ See Castro 2005, 9-30; Domingues 1998; Boxer 1984.

 ²³² Personal communication, Ronald H. Towner, 15 March 2010; this includes the extremely successful dating of archaeological features from the U.S. Southwest, which averages only 40 percent success.
 ²³³ A brief survey of *published* dendrochronological analyses on ships yields a success rate of approximately 15 percent, but unsuccessful dating attempts often (typically?) go unpublished. This rate varies significantly for time and place. Analyses in Northern Europe for the past millennia certainly have the highest rate of success.

since entire hulls are infrequently discovered and even less often are they excavated in their entirety.

Age Clusters

Evidence of age clusters in ship timbers can be used to infer forestry practices. Preliminary observations made on the timbers of the Red Bay 24M ship indicated remarkable consistency in the ages of trees from which framing members were taken. While hull planks came unremarkably from trees with a typical age of between 80 and 150 years, the frames came from trees with ages clustered around 36 to 40 years.²³⁴ Such close grouping in age is incredible: it is not feasible that such a harvest could come from a natural forest. From such close grouping in age, Loewen inferred that this is indicative of Basque naval forestry practices in the 16th century. He posited that the timber may have been grown with the exact morphology required for their purpose in a ship and harvested as a single crop.²³⁵ As the timber of the Red Bay 24M vessel had been reburied by the time of his analysis, Loewen tested the hypothesis on another Basque shipwreck from Cavalaire-sur-Mer (ca. 1490 C.E.).²³⁶ While the Cavalaire-sur-Mer ship demonstrated a somewhat less strong relationship, it was still significant: 72 percent of framing timbers studied (floors, first and second futtocks) were harvested at 65 years of age, ± 5 years.²³⁷ Not surprisingly, contemporary archival records confirmed that frame timbers (but not hull planks) had been shaped by forest workmen in the Basque region at

²³⁴ Loewen 2000, 147, n. 13.

²³⁵ Loewen 2000, 147.

²³⁶ Loewen and Delhaye 2006.

²³⁷ Loewen and Delhaye 2006, 103.
the time the above ships were built.²³⁸ Due to the age of the timbers, it can also be concluded that the practice began at least as early as 1400-1420 C.E., a century prior to the earliest written evidence of the practice, and continued into the 17th century.²³⁹

Despite the potentially great utility and simplicity of the method, I am aware of only the above examples. This method can be of particular usefulness because it does not require a fixed dendrochronology for the time, place, or species. While an absolute chronology could yield results with greater levels of confidence, counting rings on the timbers should be sufficient to produce the data necessary for basic analysis. These data are easily presented and interpreted in bar graphs.

Reuse

Reuse of timber in a ship is typically interpreted as a sign of resource stress. However, reuse can also be motivated by practical or economic decisions unrelated to timber supply. Signs of timber reuse will vary greatly over time, place, construction method, and timber location in the vessel. Comparison with historical documents, climate reconstructions (if available), iconography, and other ships is likely to produce the most reliable interpretation. For example, the ceiling planking in the Kyrenia ship was salvaged from at least three other vessels, but this may have simply been an

²³⁸ Grenier et al. 1994.

²³⁹ Loewen and Delhaye 2006, 103-4.

economical decision on the local scale, as little else in the construction of the ship indicates resource stress.²⁴⁰

Indication of reuse may be obvious or subtle. Obvious signs include unnecessary cuts or cavities, such as unmated mortises found in ancient Egyptian vessels.²⁴¹ Less obvious indications of reuse are exemplified by the timber from *La Belle*. The timbers exhibited virtually no signs of reuse on their surfaces, to the extent that the researchers were "astonished" to learn, via dendrochronology, that at least one, and likely more, of the critical structural timbers were cut approximately 200 years prior to the construction of the vessel.²⁴² Considering that the average lifespan for a ship of the period is estimated at only 20 years, such age for these timbers suggests either multiple prior uses, perhaps in other ships,²⁴³ deadwood use,²⁴⁴ or extensive stockpiling, although contemporary records do not provide evidence for the latter.

Fully understanding timber reuse can be complicated by multiple previous iterations. Often, it is not possible to interpret the date(s) or nature of a single previous use, much less multiple uses. The diverse historical applications for timbers *derived* from ships may mirror their prior uses.²⁴⁵

²⁴⁰ Steffy 1985, 86; of the hull Steffy (1985, 101) said "...this vessel certainly does not seem to be designed to conserve [timber]"; Steffy (1985, 101) posited that such patterns of reuse may be "...a reflection of the overall philosophy of the society..."

²⁴¹ Creasman, forthcoming.

²⁴² Bruseth and Turner 2004, 80, n. 23; see especially Carrell 2003, 256, 272 fig. 4-10.

²⁴³ Bruseth and Turner 2004, 80, n. 23.

²⁴⁴ See Schiffer 1986.

²⁴⁵ Ship timber has been reused for any and all purposes, from canal reinforcements (Indruszewski et al. 2006, 177, n.1) to coffins (Vinson 1994, 18-9).

Timber Conversion Studies

Timber conversion studies are useful for evaluating basic but often overlooked questions, such as the number of trees required to build a ship. Conversion analysis can also address questions related to wood technology, timber selection, quality control, and economy of timber use. Economy of timber use includes analysis of the types of cuts and percentage of wasted material based on such cuts.

In its most basic form, timber conversion studies address the amount of raw material needed to build a ship or boat. By comparing the wood grains of hull planks and framing members in a complete ship, the number and size of trees required can be reconstructed. If only a portion of the hull survives, an estimate can be made by comparison among the remaining timber to one another and extrapolation based on the remaining percentage of the hull. Such estimates should not be considered as inherently reliable.

Examples of such studies include the ancient Egyptian Dahshur boat now in Pittsburgh (ca. 1850 B.C.E.), where Ward has indicated that 18 cedar (Cedrus sp.) trees were needed for construction of the approximately 10 m long vessel.²⁴⁶ Papers from the early 15th century C.E. show that 3906 trees were cut to build King Henry V's gigantic ship Grace Dieu, launched in 1418.²⁴⁷ Ballu's calculations for King Louis XIV's ships $(3,000 \text{ mature oaks trees each}^{248})$, though based on textual documents, could easily be evaluated with the recovery and study of a period vessel. Such textual analyses were

²⁴⁶ Ward 2000, 96.
²⁴⁷ Friel 1993, 5 table 4.

²⁴⁸ Ballu 2003 20

introduced by Albion, with his study of the 100-gun first rate HMS Victory. Built in 1765, the hull timber, masts, and spars then cost £57,748 (approximately \$10,000,000 in 2010 equivalent²⁴⁹) and required more than 6,000 trees.²⁵⁰ For ships without available contemporary records, such as timber contracts, limited economic information can be used in concert with timber conversion studies to reconstruct resource costs.

Hull planking is often the most heavily worked type of timber on a ship. Although not generally reliable for interpretations of forest management (as are framing timbers, noted above), the cuts and methods of plank production can reveal wood technology, timber selection, quality control, and economy of timber use. A common hull planking material, pine (*Pinus* sp.) tends to grow long and straight, making it ideal for hull planks. Nonetheless, the conical growth of pine trunks requires substantial effort to convert to planks. Shipbuilders, and indeed anyone who regularly works with wood, quickly discover that certain cutting patterns yield certain results and should tend towards methods that optimize costs and benefits in a manner best suited to their situation.²⁵¹ Wasteful production methods suggest either an abundance of resources, whether the timber itself or another capital used to acquire timber, or sufficient need to override usual economies, perhaps a "special" purpose or client.

 ²⁴⁹ 1765 figures converted to 2010 dollars through http://futureboy.homeip.net/fsp/dollar.fsp.
 ²⁵⁰ Albion 1926, 86.

²⁵¹ See McGrail 1997, 89-101, 135-57.



Figure 11. Examples of plank cuts and quality (after Smith 1879, 386 fig. 167).

In Fig. 11, "A" cuts are of high quality and indicate high cost, and much waste. "B" cuts yield high quality timbers with less waste. "C" cuts further produce less waste, but the resulting planks are significantly lower quality than "A" cuts. "D" cuts yield large timbers of high quality.²⁵²

Basic Wood Anatomy

Knowledge of basic wood anatomy and the growth characteristics of the primary material in wooden ships can lead to better analysis. Wood anatomy studies can reveal evidence of many cultural practices, including: coppicing, pollarding (or other pruning),

²⁵² Smith 1879, 382-6; Explanation modified from Construction Work Center (n.d.,

http://www.constructionwork.com/ resources_details_1387laying_out_and_sawing_timber.html).

and training timber.²⁵³ The implication of any or all of these in association with ship timbers would suggest the employment of some form of timber management at the location where the timber originated.

For example, Loewen and Delhaye compared the "branch-free length" to the overall length of futtocks in the Cavalaire ship.²⁵⁴ All of the first and second futtocks were free of major branches. Similarly, no branches or knots were found on the framing timbers of the Red Bay 24M vessel, except at the extreme timber ends.²⁵⁵ This is a considerable achievement, as oaks do not grow this way naturally. Such regularity implies deliberate management of forest resources, in this case the pruning of lower branches and sprouts to prevent the formation of knots, which complicate shipbuilding. Accordingly, Loewen and Delhaye interpreted the lack of major branches as signs of pruning to produce better quality shipbuilding timber as part of a larger systematic naval forestry economy in which carpenters, shipwrights, and growers "observed mutually dependent practices that formed a cultural whole."²⁵⁶ Such interpretations would not have been possible had they not known about the growth characteristics of oaks.

At the microscopic level, certain timber management practices, such as pollarding and coppicing, leave distinct traces. Pollarding (cutting of branches) has been a common practice with oaks for millennia²⁵⁷ to encourage regeneration.²⁵⁸ The practice

²⁵³ Schweingruber 1993, 140-78; Haas and Schweingruber 1993; Barker 2000, 163-75; Ciciliot 2002 (as discussed in Chapter II of this dissertation); Ballu 2003, 69-85; Loewen and Delhaye 2006; Haneca et al. 2009, 7.

²⁵⁴ Loewen and Delhaye 2006, 102.

²⁵⁵ Loewen 2000, 146.

²⁵⁶ Loewen and Delhaye 2006, 100, 102-3.

²⁵⁷ See Rackham 2003.

²⁵⁸ Haneca et al. 2009, 7.

causes changes in the anatomy of the stem wood, leaving a specific signature that is observable in archaeological specimens.²⁵⁹ The signs, however, are not as obvious as those observed by Loewen and Delhaye and probably require a wood anatomist or dendrochronologist's expertise to interpret. Tree-rings from coppiced lands perceptibly differ from those of natural or dense forests.²⁶⁰

Palynology

The study of pollen, phytoliths, and other microscopic plant remains on shipwrecks and associated sediments can provide a detailed understanding of underwater site formation processes,²⁶¹ which, as noted in the previous chapter, is an important component of the process of extracting cultural information from ship timber. In addition, pollen analysis may be able to identify the season in which a ship sank,²⁶² date of construction, and a ship's home port,²⁶³ significantly increasing the usefulness or effectiveness of other timber analysis methods such as dendrochronology. Sampling from caulking, pitches and resins, ropes, and joinery areas are especially likely to retain usable spores.²⁶⁴ Such analysis will be especially useful for ships of the sewn or lashed traditions, as well as those in the clinker tradition that typically used plant or animal fibers as sealer between strakes.²⁶⁵

²⁵⁹ Bernard 1998; Bernard et al. 2006, 103-8; Haneca et al 2009, 7.

²⁶⁰ Haneca et al. 2009, 7; Haneca et al. 2006; Haneca et al. 2005.

²⁶¹ Gorham and Bryant 2001, 282-98.

²⁶² Kahanov 1996, 246.

²⁶³ Gorham and Bryant 2001, 282; Giachi et al. 2003, 269-83; Muller 2004, 343-9.

²⁶⁴ Diot 1994, 225-35; 2001, 133-40; Robinson and Aaby 1994, 167-82.

²⁶⁵ For an overview of ship's fastenings and building traditions see McCarthy (2005) and Steffy (1994, 23-188), respectively.

Although archaeological applications of palynology have been known since at least the 1940s,²⁶⁶ it has not been until the past 25 years that these techniques have been applied to maritime sites (except bogs, which have benefited for an additional 20 years), and only in the past decade with regularity.²⁶⁷ Typically, the ship timber itself is not sampled for palynological analysis, but related timber products common on ships, such as resin²⁶⁸ (pitch or bitumen, but not rosin²⁶⁹) and tar,²⁷⁰ are ideal candidates. Some concerns for maritime sites include spore preservation, potential for contamination, and sampling errors.²⁷¹ Additionally, a much larger base of voucher samples will be required from broader geographic regions in order to source locations on a large scale.²⁷²

At least 19 ships found at the ancient harbor of Pisa have been the subject of perhaps the most successful palynological analysis, in terms of extracting cultural information about ship timber and the local environment.²⁷³ Although finds at the site date from perhaps as early as the 9th century B.C.E. (Etruscan) and well into the late 5th century C.E. (Roman), it is the Roman wrecks that have received the most study. Analysis of the clay, silt, and sand around and covering ships "C" and "F" compared to a species identification of the timber employed in the same ships' construction revealed

²⁶⁶ Bryant and Holloway 1983, 191-194.

²⁶⁷ Marshall 2007, 10-15; Gorham and Bryant (2001, 282) attribute the rise in application to three primary causes: 1) advances in techniques and technology, 2) greater emphasis on botanical remains by archaeologists, 3) increase in trained specialists.

²⁶⁸ See Loewen (2005, 238-52) for a discussion of the technological and socio-economic contexts of resinous materials related to ships, especially for the period spanning 1500-1800 C.E. in the French Atlantic.

²⁶⁹ Rosin is derived from plants other than trees.

²⁷⁰ See Carlson 2003, 589 n. 33.

²⁷¹ Gorham and Bryant 2001, 284-94; Marshall 2007, 153-5.

²⁷² Warnock 1998, 238-52; Miller's (1991, 156) statement that "[paleobotanists] need not worry about running out of work!" is still relevant.

²⁷³ Giachi et al. 2003; Mariotti Lippi et al. 2007; Bertacchi et al. 2008.

that, at a minimum, the land surrounding Pisa "would have allowed the acquisition of all the timber species used" (a total of 15 species), with fig (*Ficus carica* L.) being the only exception.²⁷⁴

A related study from the same site indicates that a reconstruction of the local flora for a given period is possible by analyzing clay sediments directly above or below a relatively dated shipwreck.²⁷⁵ Comparison of different strata can also be used to construct vegetation changes over time.²⁷⁶ Without doubt, these two approaches have direct implications for understanding ship timber, most especially its acquisition, availability, distance from shipyards, and related inquiries. Indeed, pollen analyses may even be able to reconstruct historic stand densities or expand the "known" livable landscapes for individual species,²⁷⁷ but this would require excellent preservation, probably in anaerobic environments.

The palynological investigation of three Greco-Roman shipwrecks in the French Mediterranean region provides a case study.²⁷⁸ Serge Muller tested the possibility of applying pollen analysis to resins in shipwrecks to identify a port of origin. The results were compared to resins from supposedly contemporary amphorae and wood found in terrestrial excavations. With an apparently high degree of confidence, the specific proportions of pollen recovered from the ship resins "essentially reflect[ed] the arboreal vegetation surrounding the [presumed] shipyards."²⁷⁹ The results are touted as evidence

²⁷⁴ Giachi et al. 2003, 269, 272.

²⁷⁵ Mariotti Lippi et al. 2007, 435.

²⁷⁶ Mariotti Lippi et al. 2007, 435.

²⁷⁷ As Bertacchi et al. (2008, 181-8) have demonstrated, again at the Roman harbor of Pisa.

²⁷⁸ Muller 2004, 343-9.

²⁷⁹ Muller 2004, 343, 348.

of the reliability of pollen data for sourcing shipwrecks. Similar successes have been reported in pollen analysis from medieval shipwrecks with moss-based caulking.²⁸⁰

The archaeobotanical analysis of the Bozburun shipwreck (ca. 890 C.E.) is notable for its advances in the application of palynological and botanical study of ships as economic units, but it contributed little to the cultural interpretation of ship timbers.²⁸¹

Emerging Methods

Macrobotanical Analysis

The identification and interpretation of other macrobotanical remains on ships appear poised to contribute to the discussion of ship origins and routes, and by proxy improve interpretations of ship timber in ways similar to palynological analysis as noted above. The role of non-timber shrubs on shipwrecks is usually attributed to dunnage²⁸² or mats,²⁸³ but in at least one interesting instance of a 4th century C.E. Roman vessel, they were used as a bulge pump filter.²⁸⁴ Further study is needed in this area; these materials certainly have more to offer, though it is not likely they will directly reveal much about cultural interpretations of ship timber.

²⁸⁰ Diot 1994, 225-35; 2001, 133-40.

²⁸¹ Gorham 2000a; 2000b.

²⁸² For examples see the wrecks from: Uluburun (ca. 1306 B.C.E.), Tektaş Burnu (ca. 440-425 B.C.E.), Ma'agan Mikhael (ca. 400 B.C.E.), Marsala (3rd century B.C.E.), Madrague de Giens (ca. 70 B.C.E.); Rosen et al. 2009, 171.

²⁸³ For examples see the wrecks from: Cape Gelidonya (13th century B.C.E.) and at Tantura (9th century C.E.); see Rosen et al. 2009, 171.

²⁸⁴ Rosen et al. 2009, 163-5.

Infrared Thermography

Infrared thermography and ultrasonic velocity measurements have recently been employed to evaluate the conditions of historic architectural timbers in situ for conservation analyses.²⁸⁵ While the methods themselves, as described²⁸⁶ and employed,²⁸⁷ should not be expected to directly provide for cultural interpretation of ship timbers, it is possible that the methods could be applied to conserved timbers to assist in the identification of optimal sample locations for dendrochronological analyses. The scans could identify denser wood or better preserved areas for sampling. Good sampling is central to successful dendro-analysis, and few dendrochronologists and nautical archaeologists are conversant enough in both ship construction and dendrochronology to sample unaided. Better sampling methods should reduce the number of samples that need to be taken and increase the likelihood of permits being granted to conduct such invasive work. In the case of a large shipwreck or boat burial, establishing a quality sampling method can be difficult due to preservation, Teredo navalis, heart-rot, and other common wood afflictions. It is important to note that, at present, ship timbers cannot be successfully scanned while waterlogged, but perhaps, could be scanned if treated with PEG or other conservation methods; tests are needed. Desiccated or otherwise untreated and non-waterlogged ships, such as ancient Egyptian boat burials, would provide the optimal opportunity to test these methods.

²⁸⁵ Kandemir-Yucel et al. 2007; see also Bláha et al. 2009.

²⁸⁶ See Maldague 1993.

²⁸⁷ Radio frequency identification (RFID) has also been used in a similar manner and could be considered; however, I am not convinced it would be at all useful on ship timbers (see Cheng et al. 2008).

Charcoal Reflectance

Charcoal reflectance, a new application of measuring morphological, chemical, and physical changes in the growth layers (tree-rings) of burned wood, has been used to reconstruct evidence of burn temperature, direction, source, and other cultural phenomena in archaeological wood and wood products, such as charcoal.²⁸⁸ Originally used to reconstruct the intensity of pyroclastic flows and other forest fire events,²⁸⁹ the method can provide temperature and time of exposure for burned woods.²⁹⁰ To date, this method has been employed on few archaeological artifacts and no shipwrecks.²⁹¹ Where it has been used in an archaeological context, it has been successful, especially in identifying the original state of expended fuel, as either charcoal or simply fuel-wood.²⁹²

This method of investigation may be especially useful for interpreting burned ships and shipwrecks. Often, little evidence remains to reconstruct either the series of events, intent, or cause of burn, but the timbers themselves may be able to contribute toward such understandings. Reflectance can indicate whether a burn originated inside (for example, a galley fire) or outside (for example, an attack) of a ship. Intensity of burn will also vary based on the originating event, such as galley fire or attack. An attack using an accelerant, such as the legendary "Greek fire,"²⁹³ will burn quickly and at high temperatures, both measurable with reflectance. It is also conceivable that, with

²⁸⁸ See Braadbaart and Poole (2008) for a discussion of the morphological, chemical and physical changes during "charcoalification of wood" and its relevance to archaeological contexts; McParland et al. 2009b, 176-83; Currently, the only archaeological application of this method has been to reconstruct firing source (wood or charcoal) and burn temperatures for Roman hypocaust baths.

²⁸⁹ For example, see Collison et al. 2007, 87-97.

²⁹⁰ Scott and Glasspool 2005.

²⁹¹ Personal communication, Andrew C. Scott, 9 April 2010.

²⁹² McParland et al. 2009b, 176; Ascough et al. 2010.

²⁹³ Also known as "prepared fire," see Partington (1999) and Rodgers (1982) for more information.

experimental testing, reflectance "signatures" of recorded ship-burning circumstances could be identified.

The burned ships recently discovered at Ayn Soukhna, Egypt (dating ca. 2000 B.C.E), present an opportunity for the application of this method. Only a tentative theory has been offered to explain the "intentional" burning of the vessels (namely, to prevent a competing group from using them).²⁹⁴ Performing charcoal reflectance on specimens could indicate the temperature at which the wood burned, and which, if any, substances may have been used to aid in burning/ignition, and duration of the burn. This information can be used to better infer the circumstances of the ships burning: hurried, gradual, intentional, or unintentional. Other natural and anthropogenic applications and interpretations for this method are certain to be found, but only in the past year has it been applied to archaeological materials.²⁹⁵

Chloride and Guest Elemental Measurements

The measurement and analysis of chlorides, especially sodium chloride, and guest elements in the cells of ship timbers may aid in evaluating a basic but very difficult question regarding acquisition of the raw material: how far inland was wood harvested? In societies that did not rely on the wheel, pack animals, or have inland rivers down which to float timber, this could be a significant limitation to the industry. Is there a terminal distance after which builders find it is simply easier to relocate the build site?

²⁹⁴ Abd el-Raziq 2008, 2 April; personal communication (conference lecture), Patrice Pomey, 12 October 2009, *ISBSA* 12, Istanbul, Turkey.

²⁹⁵ See McParland et al. 2009a.

Are certain species worth pursuing at greater distances, and, if so, how far? We know that the Portuguese shipbuilders of the 16th century regularly bought pine for masts in Germany, said to come from Riga.²⁹⁶ The above questions have significant cultural implications but as yet no method of analysis.

Research evaluating the ebb and flow of estuary environments by comparing chloride concentrations in the growth rings of baldcypress (*Taxodium distichum*) are promising, as they reflect the change in saltwater inundation at a fixed location (in this case, a grove).²⁹⁷ The concept should be able to be applied to oceanic coastal regions where salinity is relatively stable, or at least predictable or deducible, and the distance inland can be calculated based on decreasing concentrations.

The above analysis is certain to be problematic on several levels in ship timber applications: there are copious records of timber being floated downstream hundreds of kilometers to a shipyard for construction or export;²⁹⁸ such analysis is not likely to work for riverine craft or craft used in fresh-water environments; and seafaring ships sail in saltwater, which may affect analysis. Nonetheless, it should be investigated further.

Dendrochemical analyses need not be limited to chlorides. Many other guest elements that could be compared to localized environments find their way into wood in measurable quantities, including potassium,²⁹⁹ calcium,³⁰⁰ manganese,³⁰¹ zinc,³⁰² and

²⁹⁶ See Costa 1997.

²⁹⁷ Yanosky et al. 1995; Conner et al. 1997.

²⁹⁸ In generally, it seems that distances of up to 650 kilometers (approximately 400 miles) would have been considered rare, and anything less than 400 kilometers (approximately 250 miles) should not be considered unreasonable (Greeley 1925, 2). These figures would certainly vary depending on time and place, with much shorter distances being more common.

²⁹⁹ Vroblesky et al. 1992.

³⁰⁰ Fisher et al. 2001.

tungsten.³⁰³ A comparative chemical analysis of the timbers within a single hull, or between contemporary hulls, may itself reveal cultural phenomena unrelated to shipbuilding (i.e., industrial activities, mining, etc.), but to date, it seems no such work has been attempted. Much is known about the standard chemical composition of common shipbuilding woods, especially the pines (*Pinus* spp.) and oaks (*Quercus* spp.), so study could progress quickly.

Tree DNA

In humans and animals, DNA has been demonstrated to be a powerful diagnostic tool; however, in other kinds of biomass, such as wood, similar studies have been extremely rare. Teams led by Rémy Petit and Marie-France Deguilloux have laid the foundations for investigations of wood DNA and found promising results.³⁰⁴ The study of chloroplast DNA (cpDNA) in oaks (*Quercus* spp.) is the most promising and may provide forest "fingerprints."³⁰⁵ When successful, the method can identify human-mediated planting of trees and track timber distribution or origin. Fortunately, in Europe, the northern portion especially, oaks have been a favored material for ships for thousands of years, and there is great potential for sourcing ship timber, as well as for providing some perspective on historic and ancient forest management practices.

³⁰¹ Beauregard et al. 2009.

³⁰² Pearson et al. 2009.

³⁰³ Sheppard et al. 2007.

³⁰⁴ See Lowe (2004) for a thorough explanation of the analysis and Deguilloux et al. (2002) for a concise review of the method and limiting factors; Deguilloux et al. 2003; Petit et al. 2002a.

³⁰⁵ Cottrell et al. 2005; Lowe et al. 2004; Nielsen and Kjaer 2008.

As recently as 2002,³⁰⁶ dry oak wood was considered the only useable material, but waterlogged material can now also be analyzed. Extracting and amplifying the cpDNA from waterlogged timber is a significant accomplishment; however, a base of comparative terrestrial specimens is also needed in order to source the material. I am aware of only two successful examples of cpDNA extracted from waterlogged shipwreck timbers: the *Mary Rose*³⁰⁷ and the vessel found at Playa Damas, Panama.³⁰⁸ The cpDNA recovered from the English Tudor flagship *Mary Rose* is likely to yield further successful results in sourcing the timbers, whereas the Playa Damas wreck lacks reasonable comparative materials. At present, it would seem that European oaks,³⁰⁹ especially British oaks,³¹⁰ are the only viable candidates for such thorough studies, despite some work with poplar (*Populus nigra*).³¹¹

Some limitations for this method are: protocols for extraction of cpDNA from waterlogged wood are still being refined; terrestrial voucher collections are still being built; it may be necessary to somehow rule out interference or contamination from underwater organisms through localized testing; and oaks are currently the only genus for which the method can be demonstrated successfully for waterlogged material. Despite these limitations, the method is extremely promising and will very likely add a new dimension for the analysis of ship timber and the interpretation of ship timbers as cultural artifacts.

³⁰⁶ Deguilloux et al. 2002, 1039.

³⁰⁷ Speirs et al. 2009.

³⁰⁸ Personal communication, Filipe Castro, 16 June 2008.

³⁰⁹ Petit et al. 2002b, 5-26.

³¹⁰ Lowe et al. 2004.

³¹¹ Cottrell et al. 2005, 71-90.

A review of the common, uncommon, and some emerging methods for the cultural interpretation of ship timber reveals that much information can be learned from a multi-faceted investigation of timbers. The series of analytical questions and tests above are intended to serve as a guide for the investigation of ship timber, which can be performed on virtually any collection (within the limits noted). The more lines of investigation that are successfully pursued, the better our understanding of the people and culture that produced the vessels is likely to be. The following case-studies evaluate the application of the above methods within their respective social, political, and economic contexts, and suggest avenues for further research.

CHAPTER IV

ANCIENT EGYPT'S MIDDLE KINGDOM

Throughout history, including today, the Egyptian Nile Valley has had one of the world's most densely concentrated populations for one primary reason: water. Given this intense association between the people and the river, it comes as no surprise that the Egyptians developed an early understanding of how to harness the gifts that the Nile had to offer. The current flowing north and winds blowing south provided a natural highway for efficient and reliable transportation. It is widely recognized that in ancient Egypt "nothing could equal a ship for carrying capacity and reasonable speed."³¹² Egypt derived much from its successes from the water, and not only the river but the adjacent seas as well.

Social, Political, and Economic Circumstances

The Middle Kingdom (ca. 2060-1650 B.C.E.³¹³) is generally considered to comprise part or all of three dynasties, the latter portion of the 11th (2060-1985 B.C.E.), the 12th (1985-1773 B.C.E.), and the 13th (1773-1650 B.C.E.), which overall corresponded respectively with the rise, peak, and fall of this division of pharaonic history.³¹⁴ For about a hundred years prior, after the fall of the Old Kingdom, Egypt

³¹² Kemp and O'Connor 1974, 101; ships were so dominant as a mode of transportation that is was not until the Roman Period that roads became widespread in Egypt.

³¹³ Establishing exact dates for ancient Egypt has been one of the most difficult tasks assumed by Egyptologists since Manetho's *Aegyptica*, the first modern history of the pharaonic era, dating to the 3rd century B.C.E. Dates provided here are approximate.

³¹⁴ A detailed account of the Middle Kingdom can be found in Grajetzki (2006) and a brief overview by Callendar (2000), both of which have been drawn upon for the summary below.

existed politically as a pair of competing dynasties,³¹⁵ with the result of a proliferation of local cultural traditions. The Middle Kingdom witnessed renewed political and cultural unity under the Theban kings of the last portion of the 11th Dynasty. While many specifics, including chronological matters such as coregencies, individual reign lengths, and absolute dates, remain imperfectly preserved and much debated, the broad historical outline is largely agreed upon.

Mentuhotep II established what later authors would call the Middle Kingdom when he succeeded Intef III on the throne at Thebes and, after a period of military struggle, completed the reunification of Egypt. This king created or reinstated a series of political posts modeled on those of the Old Kingdom, which consolidated power at his Upper Egyptian capital. Centralization of power became a constant trend throughout the Middle Kingdom, as did expansion of Egyptian influence into the Levant and especially Nubia. The next two kings, Mentuhotep III and Mentuhotep IV, present less evidence in the archaeological and historical records, although the former appears to have been a prolific builder. However, mining and quarrying expeditions into the deserts and Sinai were recorded, and the first Middle Kingdom voyage to Punt, typically referred to as "the land of wonderful/exotic things," occurred under Mentuhotep III.

The dawn of the 12th Dynasty came with the crowning of Amenemhat I, who had possibly served as Mentuhotep IV's vizier. Continuing activities he had overseen as the senior official during the previous reign, Amenemhat I secured the country's borders and undermined the power of the nomarchs (regional governors). For reasons not

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³¹⁵ Ruling in the north at Memphis or, later, Herakleopolis, and south at Thebes.

entirely clear but possibly in part related to campaigns against foreigners in the Delta, he moved his royal city from Thebes to the area of modern Lisht, at the border of Upper and Lower Egypt and near the Faiyum. After approximately 30 years of rule Amenemhat I died, possibly at the hands of an assassin, and was succeeded by his son, Senwosret I.

Senwosret I continued the economic and social growth of the dynasty by sending expeditions to Asia and renewing frequent trade with Syria. His establishment of the fortress at Buhen, at the Second Cataract, made gold-rich Lower Nubia an extension of Egyptian territory. Senwosret I's building program, in which monuments were erected at cult sites throughout Egypt over the course of his 45-year reign, encouraged the establishment of a single unified material culture, intentionally reminiscent of the Old Kingdom.³¹⁶

The similarly long rule of about 35 years of Senwosret I's successor, Amenemhat II, is not as well documented. Trade with the Aegean is, however, evident. The rule of the next king, Senwosret II, lasted for a comparatively short but prosperous eight or nine years. During this time there was a distinct lack of military action—or perhaps a lack only of records—which possibly permitted more time to be spent on other affairs of state, including Levantine trade and the institution of an irrigation system in the Faiyum region. After Senwosret II, what has been called the "high Middle Kingdom" commenced with the reign of Senwosret III.

A very prosperous time for Egypt, Senwosret III's rule, lasting perhaps 29 years, was responsible for an expansion of the empire in all directions, massive centralization

³¹⁶ See Vercoutter (1967) for evidence.

of government, and growth in trade. During his eighth year, he undertook the first of several Nubian campaigns, beginning with the clearance of a canal 150 cubits long, 20 cubits wide, and 15 cubits deep at the First Cataract in order to sail his armies up the river. Most of Senwosret III's military activity was concentrated in Nubia, where Egyptian rule was expanded and the native population and trade were strictly regulated, but textual evidence also points to campaigning in Asia. Furthermore, other monuments record ventures east to the Red Sea and Punt, north to re-open Sinai copper mines (copper being a critical resource in the Bronze Age), and west into the Libyan Desert.

To centralize political power within his court, Senwosret III created an extraordinary bureaucracy with, among others, departments of Upper and Lower Egypt, treasury, labor, military, vizier, and the "bureau of the people's giving." Each required not only a bureau chief but numerous other functionaries of various levels. The sons of nomarchs received appointments at court or otherwise away from their home provinces, thus minimizing the influence of these families, whose power previous kings had already degraded.

Building on the vast successes of his father, Amenemhat III reigned for approximately 46 years, probably including a lengthy coregency with Senwosret III, bringing further cultural expansion to Egypt. No records of significant military activity during Amenemhat's reign are known and it is assumed that his father's military actions were largely responsible for establishing the kingdom's subsequent lengthy period of peace. During this time building projects included the king's ambitious tomb complex at Hawara, as well as temples, and shrines. Numerous mining expeditions were sent out to

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various locations in Sinai, Egypt, and Nubia. Additions were made to the Nubian fortresses. Several low annual floods toward the end of his reign might have hastened the economic decline of the dynasty.³¹⁷ It was also during his rule that an Asiatic population settled in the western Delta, and their descendents would eventually challenge the Egyptian kings during the Second Intermediate Period.

Amenemhat III's son or grandson. Amenhotep IV ruled for only nine years, a period in which no major events are known to have taken place, although there are, again, records of mining expeditions to Sinai and also of trade with the Levant. Upon his death he was succeeded by Queen Sobekneferu who may have been his sister and was probably also his wife. Her four-year rule seemed to be effective and legitimate, as she is listed in the Turin Canon, but nonetheless the 12th Dynasty dissolved with her death.³¹⁸

Since the details of the 13th Dynasty, characterized by a large number of kings usually with brief reigns, are not particularly well known or agreed upon, nor is there agreement whether to consider the 13th Dynasty part of the Middle Kingdom, I will forgo it here. To my knowledge, there is no evidence of ship timber from this Dynasty.

Written and Pictorial Record of Timber Management

Timber was valued in ancient Egypt for its many uses,³¹⁹ and most texts indicate such commodities were held under the strict control of the king³²⁰ or his representatives

³¹⁷ Bell 1975.

³¹⁸ Bell (1975, 265-6) suggests that the Middle Kingdom did not suffer a collapse, like the Old Kingdom (see Bell 1971), but lost control gradually. ³¹⁹ Meiggs 1982, 49-87.

³²⁰ A Middle Kingdom (year 17 of Senwosret I's reign) account of a royal dockyard workshop at Thinis (Thebes) has "intense" detail and "suggests a high level of supervision in the administration" (Parkinson

and the nomarchs.³²¹ Such control likely stemmed from the need to supplement the domestic timber supply with external sources.³²² Foreign enterprise would have been the king's prerogative and likely prohibitively expensive for all but a minute fraction of the nobility. Indeed, the Egyptians began importing cedar during the Predynastic period³²³ and did so in great quantities by the 4th Dynasty, as indicated by the records recorded on the Palermo Stone.³²⁴ It is apparent that through the Middle Kingdom cedar continued to be imported in similarly large quantities³²⁵ and stockpiled at royal dockyards.³²⁶

Timber imports are evidenced in various forms of art, especially tomb paintings and reliefs,³²⁷ but these tend to be of limited utility for analysis. Most trees depicted in ancient Egyptian art are drawn in such general form as to be indistinguishable, especially without an accompanying textual reference providing more detail.³²⁸

Although there has been considerable scholarship devoted to accurate

translations of timber species mentioned in ancient sources, it is necessary to refer to

^{1991, 85);} see also Janssen 1975, 370-88, 539-62; Wente 1990, 59-88, especially inscriptions no. 77, 89, 99.

³²¹ This interpretation may be the result of having almost exclusively royal documents from which to interpret the situation; see Breasted 2001, 415-750; Grajetzki 2001, 2-5.

³²² Lewis 1960, 138.

³²³ Gale et al. 2000, 349; Meiggs 1982, 49-87.

³²⁴ The Palermo Stone states that, among other items, forty ships filled with cedar logs, one cedar ship of 100 cubits, and of *meru* wood, two ships 100 cubits long were brought back from the Near East, presumably Byblos, during the reign of Snefru, first of the 4th Dynasty (see O'Mera 1979; Breasted 2001, 51-72).

³²⁵ For example, a military expedition employing 20 cedar-built ships is recorded at Beni Hassan in the tomb of Khnumhotep I, a noble in the service of Amenemhet I (Newberry 1893, 84, pl. XLIV).

³²⁶ Evidenced during the reign of Senwosret I (Simpson 1965); see also Glanville (1932a, 1932b) for New Kingdom dockyard records.

³²⁷ See Manniche (1989) for many examples.

³²⁸ Lucas (Lucas and Harris 1999, 439) claimed to have been able to distinguish acacias, sycomore figs, and some palm varieties from their distinctive representations, but with the possible exception of certain palms (not evidenced for shipbuilding), I am not able to do so.

modern species terminology.³²⁹ Not only are many ancient textual references unrefined, but many wooden artifacts have not yet received modern identification;³³⁰ however, most components from ships and boats have been examined.

Native woods of sufficient quality and quantity for shipbuilding have long been assumed to be unavailable in Egypt.³³¹ This assumption has been the focus of considerable debate,³³² to which a more thorough understanding of ship and boat timbers can contribute. What seems to be generally agreed upon is that the use of local woods played a more important role in ships, but how important a role is not clear. What is certain is that several local and imported species were indeed employed in Middle Kingdom ships and boats.³³³

Ship Timber

Unlike for many other places and times, there is no reasonably reliable estimate of how many ships and boats plied Egyptian waters for any period, let alone the amount of wood required to build them, and these remain unanswerable questions. The archaeological record has, however, yielded several Middle Kingdom ships and boats. Because of the scarcity of such remains, it is critical to extract all of the data possible from their timbers.

³²⁹ An exceptional reference that provides much clarification on this issue is Baum (1988, 17-342), see also Postgate and Powell 1992; Lucas and Harris 1999, 429-56; Gale et al. 2000, 335-52; Liphschitz 2007. ³³⁰ Gale et al. 2000, 335.

³³¹ Gale et al. 2000, 334; Lucas and Harris 1999, 429; Killen 1994, 7; Lewis 1960, 138.

³³² Ward 2000, 24; Lucas and Harris 1999, 429; Dixon 1974, 205; personal communication, Samuel Mark, 15 July 2010.

³³³ See below; see also Ward (2000, 15-24) for a description of the woods.

The corpus of Middle Kingdom ship and boat timbers is comparatively rich for such antiquity and includes: disarticulated Nilotic work boat timbers from Lisht (ca. 1950 B.C.E.),³³⁴ four near-complete small Nilotic funerary boats from Dahshur (ca. 1850 B.C.E.),³³⁵ and recent finds from the Red Sea sites of Ayn Soukhna (ca. 2000 B.C.E.)³³⁶ and Mersa/Wadi Gawasis (ca. 1900 B.C.E.).³³⁷ At the time of writing, the finds from Ayn Soukhna have undergone only preliminary analysis but are expected to yield much information in the near future. The timbers from Wadi Gawasis are fragmentary and likely came from several vessels but are still useful. Other watercraft timbers were found at Lahun (ca. 1950 B.C.E.) in the early 20th century C.E., but excavators only noted their existence without preservation or study.³³⁸

Tool Marks

Tool marks on Middle Kingdom timbers permit a confident reconstruction of the tool kit used in their creation and subsequent vessel construction (Fig. 12³³⁹).³⁴⁰ This evidence is further substantiated by numerous finds of contemporary tools, some

³³⁴ Ward 2000, 107-28; Haldane 1992; Haldane 1988, 141-52.

³³⁵ Creasman forthcoming; Creasman et al. 2010, Creasman et al. 2009; Creasman 2005; Ward 2000, 83-102; Patch and Haldane 1990; De Morgan 1895, 82-5.

³³⁶ Abd el-Raziq 2008, 2 April; personal communication (conference lecture), Patrice Pomey, 12 October 2009, *ISBSA* 12, Istanbul, Turkey.

³³⁷ Ward and Zazzaro 2010; Bard and Fattovich 2007.

³³⁸ Petrie et al. 1923, 12, pl. 15.

³³⁹ The tool kit shown here is perhaps the most complete woodworking set from ancient Egypt; although these examples date from the New Kingdom, each of the tools are evidenced in the Middle Kingdom as well (see Gale et al. 2000, 355-6; Killen 1994).

³⁴⁰ Ward (2000, 25-30) offers a summary of these tools; despite the discovery of additional ship timbers since her work was published, no new tools have come to light; see also Goodman 1976, 17-18.

iconographic evidence (Fig. 13),³⁴¹ and even a model of a carpenter's shop demonstrating tools in use (Fig. 14³⁴²). Various sizes of bronze axes, adzes (doubling, when inverted, as planes³⁴³), chisels, drills, and pull saws employed in ship construction have left their evidence directly on timbers (Fig. 15).³⁴⁴ Polishing stones were likely also used on the surface of the wood,³⁴⁵ and wooden mallets would have struck chisels and driven tight-fitting tenons into mortises. Whetstones kept the implement edges sharp. All of the extant ship and boat timbers demonstrate the use of some or all of these tools, with those of the Dahshur boats being the most revealing, due to their good preservation.³⁴⁶

³⁴¹ Little shipbuilding iconography is known from the Middle Kingdom, this being the most "active" scene, from the tomb of Khnumhotep III.

³⁴² See Winlock (1955, pl. 28) for further information on the Meketre models.

³⁴³ Lucas and Harris 1999, 449; Personal communication (conference lecture), Geoffrey Killen, 10 May 2010, *Experiment and Experience*, Swansea, Wales. The plane has not been evidenced archaeologically, iconographically or textually during any phase of the pharaonic period. This is an important distinction that cannot likely be made by investigating the tool marks on the timbers out of context.

³⁴⁴ See Creasman forthcoming; Ward and Zazzaro 2010, 12; Creasman 2005; Ward 2004, 2000.

³⁴⁵ Ward and Zazzaro 2010, 12.

³⁴⁶ See Creasman forthcoming; Creasman 2005, 65-6, 106-7; Ward 2000, 83-102.



Figure 12. Woodworking tool kit from Thebes, ca. 1300 B.C.E. (British Museum, London. EA 6046, 6040-43; courtesy of and copyright Trustees of the British Museum).



Figure 13. Middle Kingdom ship construction scene (from Newberry 1893, pl. XXIX).



Figure 14. Meketre's model carpentry shop, 11th Dynasty (after http://wysinger.homestead.com/nubianarchers.html, 20 May 2010).



Figure 15. Adze marks on a deck plank from the Red boat, GC 4926, from Dahshur (Author; courtesy The Egyptian Museum, Cairo).

Assembly and Construction Marks

Middle Kingdom timbers preserve little evidence of assembly and construction marks, but what can be identified is consistent with the deliberate nature of Egyptian construction practices. Incised marks found on disarticulated (hull?) planks and a single standard hieroglyph chiseled into a deck plank found at the port/way station at Wadi Gawasis *may* relate to construction methods.³⁴⁷ Despite the lack of larger context in this case, the argument is buoyed by the assembly marks from the Khufu I vessel, as discussed in Chapter III. It should, however, be duly noted that the Wadi Gawasis timbers are largely refuse and have no matching pairs to confirm assembly correlations.

Black painted lines indicating the planned loci for mortises on some of the hull planks of the Pittsburgh Dahshur boat³⁴⁸ were almost certainly cutting guides laid by a master and left for the apprentice or laborer to chisel away. Such organization should not be unexpected in ancient Egyptian shipbuilding and perhaps mirrors a philosophy of preparation like that employed in architectural construction and decoration.³⁴⁹ Construction of a ship would have no more been the responsibility of a single person than would a tomb or temple.³⁵⁰ This, therefore, calls for methods of work division and delegation. Marking timbers with paint for certain cuts and sending them through an assembly-line-like process *could* have been efficient and taken advantage of a large pool of laborers available to a king, like those who built the pyramids. Such laborers could

³⁴⁷ Ward and Zazzaro 2010, 12.

³⁴⁸ Ward 2000, 92-3 fig. 41.

³⁴⁹ For example, see Eyre (1987, 167-221) for a study in organization of labor during the New Kingdom.

³⁵⁰ Robins 1994, 30.

have been trained at different levels of woodworking, which would be generally consistent with the highly centralized nature of the society.

The non-structural half-mortise-and-tenon joints at butt joints of hull planks in the Dahshur boats provided a similar opportunity.³⁵¹ The shipbuilder(s) could use these guides to place a timber, or timbers, without the necessity of firmly securing them by standard mortise-and-tenon joints. If necessary, the timbers could be removed, adjusted, and replaced as many times as needed until the correct hull shape was achieved.

Timber Size and Shape

The circumstances of Egyptian timber resources, including the limitations (e.g. of available size) of local species and the expense of importing better wood, encouraged compensating technological advances in wooden ship construction.

The Dahshur boats, approximately 10 m in length, lack the panache associated with most royal ceremonial endeavors, especially the funerary rituals to which they are attributed.³⁵² In light of not only the Old Kingdom funerary vessel of Khufu (43.5 m in length),³⁵³ but also the working seagoing ships of Snefru (100 cubits, approximately 52 m),³⁵⁴ other ships built of local timber (also reaching a reported 100 cubits, or 52 m),³⁵⁵ and even the dimensions of the seagoing ship noted in the Middle Kingdom tale of *The*

³⁵¹ Fred Hocker is credited with advancing the "temporary fastening" concept, see Ward 2000, 85-9 fig.
38; Creasman 2005, 39-53, 86-127, fig. 16.

³⁵² See Creasman forthcoming.

³⁵³ See Mark (2009) for a recent synthesis and reanalysis of the Khufu I vessel.

³⁵⁴ Recorded on the Palermo Stone, mentioned above; see also O'Mera 1979; Naville 1903.

³⁵⁵ Lichtheim 1973, 21-32.

Shipwrecked Sailor (reportedly 120 cubits, approximately 62.5 m),³⁵⁶ the small Dahshur boats raise a number of questions. Could the king, Senwosret III, acquire only small timbers,³⁵⁷ most of which had been used at least twice before?³⁵⁸ Given that local species were available in lengths of up to eight meters at least into the New Kingdom,³⁵⁹ it raises some question as to their availability in earlier periods. The critical question being: how much *quality* timber could be provided locally in a given period, and could such provisions keep pace with demand?³⁶⁰

Senwosret III ruled during a period of widespread and robust international commerce, so it is not likely that there was an interruption in the foreign timber supply.³⁶¹ One possible explanation, therefore, might be that the rulers of the Middle Kingdom did not indulge in many of the excesses of their Old and New Kingdom counterparts. This idea is reinforced by the use of mud brick, rather than stone, in pyramids and by the appearance of humanizing royal art in the 12th Dynasty.³⁶² I do not believe that the modest size of the recovered boats of the period reflects limited

³⁵⁶ Papyrus St. Petersburg 1115; for a popular version see Foster (1998); the story is considered by many scholars to be fanciful, but in comparison to Khufu I the figure does not seem unreasonable.

³⁵⁷ For example, of the approximately 99 structural timbers used in the construction of the Cairo Dahshur boats, only one exceeds 4 m in length. The majority, 51, are less than 2 m, 39 timbers are between 2 and 3 m, and 8 are between 3 and 4 meters (Creasman and Doyle 2010, 24). The Khufu I vessel has timbers that exceed 20 m in length (Lipke 1984).

³⁵⁸ See Creasman (forthcoming) and below for indications of reuse.

³⁵⁹ Janssen 1975, 373-5; Gale et al. 2000, 367.

³⁶⁰ I am not aware of any ancient text or other reference that provides such information or analysis.

³⁶¹ Callendar 2000, 137-71.

³⁶² Old and early Middle Kingdom kings were almost never depicted as anything other than virile and idealized, while the majority of Senwosret III's depictions show a man with furrowed brow, large ears, and other "flaws."

materials but instead indicates broader philosophical changes toward more responsible stewardship, or at least less irresponsible stewardship.³⁶³

Did Egyptian shipbuilders make good use of available timber resources, as evidenced by the use of joggling (the Lisht timbers³⁶⁴) and top-and-butt joinery (Dahshur boats) in hull planking?³⁶⁵ These planking methods had the (primary?) advantage of redistributing stresses and cannot be attributed to timber conservation alone, given that the timbers of the Dahshur boats were shaped in a manner that wasted a significant amount of wood.³⁶⁶ Yet, it is possible, perhaps even likely given the extensive signs of reuse evidence on some of the Cairo Dahshur boats³⁶⁷ that the boats' timbers were themselves shaped from serially reused wood. Repetitive reuse may create comparatively little waste for any single iteration, but would otherwise appear to a later investigator as a single event with excessive waste.

Species Identification and Use

Written records from the whole of the pharaonic period indicate the employment of no fewer than 16 different woods in ancient Egyptian ship and boat construction, excluding reed craft.³⁶⁸ Far fewer species have been archaeologically attested to in

³⁶³ Samuel Mark (personal communication, 15 July 2010) proposes that this situation might be more complex, and that several other possibilities exist. The possibility presented above is one that I believe explains the available evidence. Another possibility is that boat burials may have had less significance in the Middle Kingdom than the Old Kingdom, thus the resultantly smaller vessels: see Creasman (2005, 5-6) for a discussion of the miniaturization of watercraft in ancient Egyptian tombs through time.

³⁶⁴ See Ward 2000, 127 fig. 71.

³⁶⁵ See Steffy (1994, 291) for clarification of the terms.

³⁶⁶ Most were hewn from the core of trees; Ward 2004, 14.

³⁶⁷ Creasman forthcoming.

³⁶⁸ Gale et al. 2000, 335-52; a good guide for the characteristics of woods commonly found in Egypt, their properties and how to recognize them can be found at: http://www.digitalegypt.ucl.ac.uk/wood/types.html.

nautical construction. Most ship components for Middle Kingdom timbers have been subjected to species identification (Table 1). However, in some cases this has occurred only recently. The wood of the Cairo Dahshur boats did not undergo scientific identification until 2006, when a small selection of hull planks from both vessels was identified as *Cedrus libani*,³⁶⁹ as had long been suspected. For new discoveries, such as those at Wadi Gawasis and Ayn Soukhna, species identification is standard procedure.

Cedar³⁷⁰ is the predominant species in Middle Kingdom hulls, including most the wood from the four extant Dahshur boats,³⁷¹ ship parts at Wadi Gawasis,³⁷² and two hulls at Ayn Soukhna.³⁷³ Locally available timbers would not have fit the necessary level of prestige for ceremonial river craft, while the resins in cedar make it preferable for seagoing vessels. The joinery components, however, especially tenons, tend to be constructed from a denser and sturdier local wood, typically acacia (*Acacia nilotica*), sycomore (*Ficus sycomorus*), or tamarisk (*Tamarix* sp.). This relationship suggests that the Egyptians were aware that cedar, while ideal for hull planks, was too soft to stiffen the vessels and serve "in the manner of little internal frames," as Steffy phrased it,³⁷⁴

³⁶⁹ Nili Liphschitz, Institute of Archaeology, The Botanical Laboratories, Tel Aviv University. 23.02.2006; testing kindly facilitated by Cemal Pulak.

³⁷⁰ The merits of cedar as a shipbuilding material have been clearly stated by Pulak (2001, 24-36), Ward (2000, 20-2), and Gale et al. (2000, 349-50, 367-8), and need not be reiterated here.

³⁷¹ Creasman forthcoming; Ward 2000, 92: the Dahshur boats are generally believed to have been used in some aspect of Senwosret III's funerary procession, and thus, as sacred objects, should have been built of only the most valuable timber, as, indeed, they were: cedar.

³⁷² Gerisch et al. 2007, 185-8.

³⁷³ Personal communication (conference lecture), Patrice Pomey, 12 October 2009, *ISBSA* 12, Istanbul, Turkey.

³⁷⁴ Steffy 1994, 33.

especially when better materials were available locally. Acacia, sycomore, and tamarisk grew abundantly in Egypt until the medieval period.³⁷⁵

Site/Boat	Hull	Deck	Frames	Tenons	Other
Ayn	Cedrus sp.	?	?	Acacia sp	?
Soukhna	Quercus sp.			-	
Mersa/Wadi	Cedrus	Cedrus	Cedrus	Acacia	Faidherbia
Gawasis	libani	libani, Ficus	libani	nilotica	albida,
		sycomorus,			Avicennia
		Acacia			marina,
		nilotica			Pinus sp,
					Quercus sp.
Lisht	<i>Tamarix</i> sp.		<i>Tamarix</i> sp.	<i>Tamarix</i> sp.	
	Acacia sp.		Acacia sp.	Acacia sp.	
Lahun	?	?	?	?	?
Pittsburgh	Cedrus	Cedrus	n/a	<i>Tamarix</i> sp.	
Dahshur	libani	libani			
Chicago	Cedrus	Cedrus	n/a	Likely	
Dahshur	libani	libani		<i>Tamarix</i> sp.	
White Cairo	Cedrus	Likely	n/a	Likely	
Dahshur	libani	Cedrus sp.		<i>Tamarix</i> sp.	
Red Cairo	Cedrus	Likely	n/a	Likely	
Dahshur	libani	Cedrus sp.		<i>Tamarix</i> sp.	

Table 1. Condensed timber species and uses (see Appendix).

The identification of the Lisht timbers as tamarisk and acacia³⁷⁶ provide a contrast to the cedar-built ships. These are the disarticulated remains of what was probably an 11th Dynasty work boat, to judge by the robust nature of the native timbers and their eventual re-use in a construction ramp. The Lahun timbers were likely similar.

³⁷⁵ Gale et al. 2000, 367. ³⁷⁶ Ward 2000, 110.

With regard to species identification and vessel purpose, Ward posited two categories of wooden watercraft: 1) ceremonial and seafaring vessels built of imported cedar and 2) more economically significant freighters and other working boats created from the abundant local supplies of tamarisk and acacia.³⁷⁷ This dichotomy stems from both function of construction style and intended use. Work boats for the Nile could make use of smaller planks of lower quality as the Nile is calm and predictable.³⁷⁸ Additionally, the Nile lacks the shipworm and thus a resinous wood is not necessary. The use of cedar in the seas may have been necessary owing to the presence of shipworms.³⁷⁹ As for the use of cedar in ceremonial vessels, it cannot go overlooked that such vessels were almost certainly displays of power and building them from valuable imported wood would have been a conspicuous demonstration.³⁸⁰

Some diversity from the core resources of cedar, acacia, and tamarisk can be found in ship construction. At Wadi Gawasis, ship timbers include previously unknown Egyptian uses of apple-ring acacia (*Faidherbia albida*) and mangrove (*Avicennia marina*),³⁸¹ although in apparently small quantities, perhaps indicating repairs *en route*.³⁸² At Ayn Soukhna, two presumably seafaring ships included at least two oak (*Quercus* sp.) planks, but the bulk of the timbers are cedar.³⁸³

³⁷⁸ See the Lisht timbers in Ward (2000, figs 70, 71) and Haldane (1992, pl. 102-8, 115-33)

³⁷⁷ Ward 2004, 14.

³⁷⁹ Shipworm was clearly a problem for seafaring vessels as demonstrated by the ca. 47 liters of debitage and gribble from Wadi Gawasis (see Bard and Fattovich forthcoming).

³⁸⁰ Ward 2004, 14.

³⁸¹ Gerisch et al. 2007, 185-8.

³⁸² Ward and Zazzaro 2010, 5.

³⁸³ Personal communication (conference lecture), Patrice Pomey, 12 October 2009, *ISBSA* 12, Istanbul, Turkey; at date of writing no further information has been published, including scientific names and location of the oak planks (i.e. hull, deck, etc.).

Reuse

Wood, especially imported luxury material, was sufficiently valuable to prompt, when possible, its reuse. Recent finds and analyses are developing a more complete understanding of the apparently common practice of timber reuse in watercraft, including royal ships made of imported timbers. The practice appears early, likely even on the grand Khufu I vessel,³⁸⁴ and in the Middle Kingdom it seems to be the rule rather than the exception.

Reuse can take many forms and not need be limited to multiple applications of the timber in ships. The Lisht and Lahun timbers provide excellent examples of non-nautical reuse of ship timbers. Boats, perhaps Nilotic barges,³⁸⁵ were disassembled and used to reinforce at least *six* separate quarry- and construction-related slipways near Middle Kingdom pyramids.³⁸⁶ Ward attributes multiple stacked mortises (similar to that seen in Fig. 16) to "miscalculation" in construction, but it is possible that this is evidence of previous use. The timbers also offer evidence of repair: a trapezoidal plug was used to tighten a joint that had come loose over time.³⁸⁷

Another kind of reuse appears at Ayn Soukhna. The ship timbers were intentionally and carefully laid out, bound in groups, and stored elevated from the ground, similar to the packing of the Khufu I vessel timbers.³⁸⁸ Pomey has convincingly suggested that this sort of arrangement was for storage between expeditions, and the

³⁸⁴ Mark 2009, 149-50.

³⁸⁵ Haldane 1992, 102-12; Ward 2000, 107-8.

³⁸⁶ Lahun see Petrie et al. (1923, 2, 12, 34, pl. XIII and XV); Lisht see Arnold (1991, 86-92; 1992, 92-5, 102-112, especially supplementary map VI).

³⁸⁷ Ward 2000, 112.

³⁸⁸ Pomey 2009, 2.
timbers were intentionally burned, probably to prevent further reuse.³⁸⁹ Further details regarding investigations of the timber may yield further information.



Figure 16. Evidence of reuse: mortises stacked four deep, with at least five iterations. (Author; courtesy The Egyptian Museum, Cairo)

Wadi Gawasis provided evidence of yet another method by which the Egyptians reused timbers. At this site, pieces of wood debitage from ancient ship repairs have red paint outlining areas of planks that needed to be removed, typically due to shipworm damage.³⁹⁰ It would not be necessary to remove the damaged areas if the wood was not intended to be used again in some fashion, whether in a ship or not. Hull and deck planks have numerous, and in some cases overlapping, mortises. Since the finds do not represent a clear construction method, single pattern, or single vessel, it is difficult to conclude if these are signs of reuse or some not-yet-understood seafaring adaptation of the more familiar Nilotic tradition of boatbuilding. However, a brief personal inspection

³⁸⁹ Pomey 2009, 2.

³⁹⁰ Ward and Zazzaro 2010, 12.

of several dozen of the Wadi Gawasis timbers in December 2006³⁹¹ provided me with opportunity to compare this evidence with that presented by the Cairo Dahshur boats (described below). It is my opinion that many of the timbers viewed had been reused at least twice, and some likely more often, but in what context is not known.

Repurposed timber comprised at least 60 percent of the planks in the Cairo Dahshur boats.³⁹² The figure is probably much greater, but the state of preservation and absence of some timbers prevents a complete analysis. Surplus unmated mortises, which have tempted researchers to dub these vessels "wretched"³⁹³ or "ill-conceived,"³⁹⁴ may indicate reuse rather than lack of quality.³⁹⁵ In the extreme, exemplified on the Red boat from Dahshur,³⁹⁶ some unmated mortises are stacked up to four deep on a single hull plank (7.5 cm wide) and reflect at least five previous uses or attempts (Fig. 16). Such profuse evidence of emendation suggests that the trees providing the timber that eventually went into these boats were felled considerably earlier than the end of Senwosret III's reign. For example, on the Red boat, two beams near midships have peg holes, but there are not enough deck planks of sufficient size with peg holes to match: this is likely evidence of timber reuse. For what purpose the timbers were previously crafted cannot be determined at present. Dating the ancient tenon fragments in mortises

³⁹¹ By the kind invitation of Kathryn Bard (site Co-PI, with Rodolfo Fattovich) and with the assistance of Chiara Zazzaro, for which I am most grateful.

³⁹² Creasman forthcoming.

³⁹³ Jenkins 1980, 84.

³⁹⁴ Landström 1970, 90.

³⁹⁵ Steffy 1994, 33.

³⁹⁶ The clarification of "Red" and "White" titles for the Cairo Dahshur boats is one of the primary themes in Creasman (forthcoming). For reference, the Red boat is GC 4926 and the White boat is GC 4925.

without corresponding mates would yield the best estimate of when they were previously used.

Repurposing and reuse are almost certain to create misleading radiocarbon dates for these hull timbers. Not surprisingly, radiocarbon dates from the Chicago and Pittsburgh Dahshur boats yielded a wide range of dates clustered around the 20th and 19th centuries B.C.E.,³⁹⁷ but according to Ward these boats appear not to exhibit as high a rate of reused timber as those in Cairo. I am not aware of any radiocarbon dating of the Cairo boats.

Peter Ian Kuniholm made significant progress in demonstrating that dendrochronology would be a reasonable pursuit despite inherently limiting factors for the period and species.³⁹⁸ He sampled ("cored") the Pittsburgh Dahshur boat in the early 1990s C.E., but it was not until 2000 C.E. that he was able to collect sufficient related material to fully understand the implications of the boat's tree-ring data. He derived two long ring series: 336 years from the hull planks and 400 years from the deck planks, for a combined length of 523 calendar years.³⁹⁹ These results went overlooked for application for nearly a decade because they did not correspond well to the "known" date range for Senwosret III. Recognition of the fact that "the wastage of trimmed-away wood on the [deck planks] in [the Pittsburgh Dahshur boat] is extraordinary" and that the hull planks too were "very heavily trimmed"⁴⁰⁰ resolved the concern about *how* the timbers fit the growing chronology, despite a nearly 200-year disconnection between the

³⁹⁷ Ward 2000, 83.

³⁹⁸ Kuniholm 2001a, 79-81.

³⁹⁹ Kuniholm 1992, 31 January.

⁴⁰⁰ Kuniholm 2001, 81.

two data sets taken from a single vessel. Once Kuniholm acknowledged that the data could indeed be reliable and broad, efforts were made to place it within the larger chronology. The boat timber chronologies were found to overlap with several other contemporary artifacts from Egypt, including a coffin and a wooden sarcophagus.⁴⁰¹ It is significant to note that these matches both dated to the 11th Dynasty and the boats were the key to bridging a chronology that exceeds 1,200 years.

Timber Conversion Studies

From the Middle Kingdom, the vessels which at the moment provide the most reliable timber conversion studies are the Dahshur boats, as they are nearly complete.⁴⁰² Because only fractions of (presumed) hulls can be reconstructed from Lisht and Wadi Gawasis, timbers from these two sites would provide more problems than benefit in such analysis. More material is needed and generally must be placed in the context of a hull so that the portion remaining of the vessel can be calculated and thus timber estimates subsequently extrapolated. In the case of the Dahshur boats, it is estimated that at least 18 mature cedar trees were required for each hull, its beams, and deck planking.⁴⁰³ This estimate was achieved through dendrochronological comparison of timber grains, by which portions of a single tree can be identified.

Dendrochronological analysis can be extremely informative regarding timber conversion and the amount of waste-wood produced in the obtainment of construction

⁴⁰² Once excavated and reconstructed the Ayn Soukhna ships should also be useful in this respect.

⁴⁰¹ Kuniholm 2001, 80-1.

⁴⁰³ M. Newton's estimate for the Pittsburgh boat (Ward 2000, 96).

materials. Kuniholm's analysis of the Pittsburgh Dahshur boat confirmed not only that a great percentage of wood was wasted in the boat's construction but also that much of the wood employed was reused. These two points would seem contrary, but, as suggested above, this may be further evidence of the trend towards better stewardship of the resources available to Senwosret III. It is possible, perhaps even likely, that these timbers were imported significantly before Senwosret III's reign and derived from other vessels or structures. Their initial applications would be the cause of the "extraordinary" waste Kuniholm found, and their subsequent reuse(s) could be explained by an intent to preserve materials. Whatever the reason, the result is clear: massive timber waste followed by a high rate of reuse.

Dendrochronological analysis also demonstrated that opposing port and starboard bulwark planks were cut from the same tree, probably to encourage symmetry in hull shape.⁴⁰⁴ It is not surprising that the shipbuilders employed this practice, and, except where reuse is prevalent, it is probably common throughout the four hulls; however, only the Pittsburgh hull has been sampled for analysis. Matching distinct knot and grain patterns in the remainder of the hull suggests that symmetry was practiced elsewhere on the Pittsburgh boat.⁴⁰⁵ The rate of reuse in the Cairo Dahshur boats obscured such initial analysis, but these timbers should still be reexamined specifically for this trend. The Chicago boat, being the least studied and best preserved of the Dahshur group, would be an ideal candidate for such analysis.

⁴⁰⁴ Ward 2000, 96.

⁴⁰⁵ Ward 2000, 96; this method is incredibly underused in the analysis of ship timbers. Many investigations of timber do not record knots and grain patterns in their one-to-one timber drawings, even when such drawings exist. This utility makes a good case for the practice.

Timber conversion studies can also reveal the methods used to shape the timber and the quality of cuts.⁴⁰⁶ Ceremonial vessels appear to have higher quality cuts that consumed a greater quantity of material. For example, many timbers in the Cairo Dahshur boats were hewn from or near the center of a large tree, and much waste wood was produced. Kuniholm found a similar relation for the Pittsburgh boat, as noted previously. On the other hand, the Lisht timbers, from a work boat, were cut so that an "economy of wood use is evident."⁴⁰⁷ The carpenters cut the timbers strategically to avoid major knots, compression wood,⁴⁰⁸ and to take advantage of the natural grains and curvatures, presumably to maximize strength and minimize weaknesses.

Summary

While there are still several avenues for research available for Middle Kingdom timbers, including relative timber ages, age clusters, wood anatomy, and especially dendrochronology,⁴⁰⁹ it appears that some awareness of the finite nature of shipbuilding wood was acknowledged and measures were taken to address this constraint. Reuse, in some form, occurs for all known ship timbers from the period. Locally grown timbers were cut with greater attention towards timber conservation (for the greatest, or necessary, balance of quality and quantity), probably reflecting the vessels' importance

⁴⁰⁶ See Gale et al. (2000, 354-70) and Killen (1994, 12-8) for the most thorough analyses of ancient Egyptian timber preparation methods.

⁴⁰⁷ Ward 2000, 110.

⁴⁰⁸ Compression wood can cause significant structural problems (e.g. cracks) if not prepared appropriately. Compression wood is prevalent in cedars especially (see Pulak 2001, 24-5), and if *not* present likely indicates one or more of the following: a thorough timber selection process; some form of tree management, such as removing limbs during growth; or extreme timber waste to reach to core of a large tree where compression wood is less significant.

⁴⁰⁹ The absence of an absolute chronology has led to significant dispute about the order and timing of many events, epitomized by conflicts noted in Kitchen (1991, among many others) and Wiener (2006).

in the economy, whereas imported timbers were cut to maximize quality with apparently little regard to cost; this is probably reflected their infrequent use and already disproportionate expense.⁴¹⁰

When interpreting timber from other periods of Egyptian history (or any place/period with only one kind of vessel evidenced), the above should be kept in mind, especially for the Old Kingdom for which the ceremonial Khufu vessels provide the only ship timber evidence. It should also be noted that ceremonial timbers have survived out of proportion with working timbers, which skews the data. Cultural trends evidenced in ceremonial or imported timbers may not be representative of the practices for other kinds of ships and boats; evidence suggests that they are significantly different from those employed for utilitarian vessels constructed from local woods.

⁴¹⁰ See Ward 2004, 14-6.

CHAPTER V

THE MEDITERRANEAN UNDER ATHENIAN INFLUENCE

Athens represents the cultural zenith of the Classical period, with its influence peaking during the 5th century B.C.E.⁴¹¹ However, it was only one of a large group of independent city-states (*poleis*) that, together, comprised the Greek world. These independent units, numbering over 1,000,⁴¹² appear to have bonded together only in times of severe trouble or prosperity. These fluctuating periods of fortune were regular in and around the Aegean from the beginning of the Ionian Revolt in 499 B.C.E. until approximately 359 B.C.E. when Philip II of Macedon became king and, shortly thereafter, a unifying force. For Athens, as for many of the other poleis around the Mediterranean, social, political, and economic life was driven by success on the seas.⁴¹³

Social, Political, and Economic Circumstances

The classical Greek economy was thoroughly embedded in sociopolitical relationships.⁴¹⁴ The poleis were founded on an agrarian lifestyle in which self-

⁴¹¹ The Persian War, 490 to 480 B.C.E., established Greek prominence in the Aegean over the Persians. This Athenian-led Greek victory enabled the *Pentekontaetia*, "fifty years' peace" (see Blackman 1969), which was later shattered by the Peloponnesian War, from 431 to 404 B.C.E. Thereafter Sparta and the Peloponnesian League supplanted Athens and the Delian League, resulting in the reshaping and eventual decline of the Greek world. Spartan-led unity was fleeting and the contemporary rise of Philip II of Macedon, and his son Alexander, effectively ended rule of the Aegean and surrounding regions by the poleis.

⁴¹² See Hansen and Nielsen 2004, 53-4.

⁴¹³ There is substantial debate regarding what constitutes and defines a thalassocracy ($\theta \alpha \lambda \alpha \sigma \sigma \sigma \kappa \rho \alpha \tau i \alpha$: "to rule of/by the sea"). De Souza thoroughly addresses these issues and concludes: "...in the second half of the sixth century... the move towards thalassocracy begins" (1998, 287).

⁴¹⁴ See von Reden 2003, 79-171; Austin and Vidal-Naquet 1980, 3-35; Finley (1999) concluded that the modern concept of a unified "economy" did not exist in ancient Greek life and instead many small competing systems operated. Horden and Purcell (2000) suggest a much greater sophistication of

sufficiency was the ideal state and commerce a necessary mode of redistribution. What a city-state could not produce it had to import, introducing an element of dependency, and it was better to be in the position of supplying what others lacked.⁴¹⁵ Thus arose a greater need for amphorae, two-handled clay containers designed for transporting commodities in bulk.

Amphorae were designed to transfer large quantities of a product over long distances; to transport hundreds or occasionally thousands of these pottery vessels and their often perishable contents long distances over land would be too consuming of time and labor to be viable except for the most expensive or exotic items. Thus arose a greater need for seafaring.

Most seafaring during the Classical period was likely in the form of cabotage, tramping from coastal city to coastal city,⁴¹⁶ without losing sight of land. Some traditional routes, such as the journey from Crete to North Africa or any trip to Cyprus, had been known for centuries, probably courtesy of the Mycenaeans and Phoenicians. These longer traditional routes following the prevailing counterclockwise currents of the eastern Mediterranean necessitated travel across the open sea, but for minimal lengths of time. A similar trend in the western Mediterranean is probably also evidenced by the Pointe Lequin IA (late 6th century B.C.E.) and El Sec (ca. 340 B.C.E.) shipwrecks.⁴¹⁷ The currents could have played a significant role in commerce by encouraging a specific itinerary of cities and thus guiding the redistribution of resources. Whitbread posed the

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commercial relationships, especially based on long-distance seafaring; see also Morris's (2003) critique of "Mediterraneanization" in the Archaic and Classical periods.

⁴¹⁵ Whitbread 1995, 9-30.

⁴¹⁶ As discussed by Braudel (2001) and Horden and Purcell (2000, 365 and especially 115-20).

⁴¹⁷ Carlson 2004, 147-8.

question: did the nature of a cargo dictate a ship's course?⁴¹⁸ Did captains chart their courses in terms of profitability?

During the Classical period the city-states and their colonies depended on one another and on local or regional allies as necessary. Perhaps the most stable unit that in some ways economically resembled other modern entities were the temples. Temples owned and leased land, harvested crops and timber, and were the recipients of various philanthropic gestures, dedications, and often taxes as well. Athens was, for most of the period under consideration, here, the most powerful polis, and its patron deity, Athena, accordingly had some of the richest temples. The city was so influential that in 454 B.C.E. the treasury of the Delian League⁴¹⁹ was moved to Athens. It seems this move was to ensure that money collected from the subordinates of the league benefited "Athena" and projects in her honor.

The Delian League maintained a large fleet for defense; Casson suggests no fewer than 400 vessels⁴²⁰ protected and encouraged the growth of its members' maritime trade. The *Pentekontaetia* and successes of the league further encouraged the growth of the island city-states, such as Samos and Thasos.

⁴¹⁸ Whitbread 1995, 27-30; similarly, Carlson (2004, 122) posed the question: did amphora shape, and therefore lading configuration dictate a ship's course? It could also be asked if amphora shape, or intended cargo in general, dictated hull shape, or did hull shape dictate amphora shape? Interestingly, Mark (2005, 63-5) points out that a transition in shipbuilding method appears to coincide with (because of?) the increase in shipping bulk cargos, especially in amphorae.

⁴¹⁹ An alliance based on the island of Delos in the Cyclades, formed in 478 B.C.E after the defeat of Xerxes and the Persians, thought it was not known in antiquity by this name.

⁴²⁰ Casson 1991, 111-2; in the same passage, Casson notes that not all of these vessels would have been fit for sea, primarily lacking crew rather than any shortage of timber.

There is no record of an Athenian navy until 482-480 B.C.E.,⁴²¹ when, at the urging of Themistocles, approximately 200 ships were built in two years as part of a larger 350-vessel force destined for Salamis.⁴²² Estimates place the number of defensive Greek vessels prior to Themistocles at no more than 70.⁴²³ From 480 B.C.E. through the remainder of the Classical period it seems that the Athenian shipyards held enough timber to build and outfit a minimum of 150 ships at any given time.⁴²⁴

In the second half of the 5th century, for many Ionian and other Aegean citystates, the threat of Persian invasion was no longer a sufficiently significant concern to merit Athenian protection. Accordingly, several of the Delian League poleis deemed the tributes required by Athens to be unfair or excessive.⁴²⁵ As some city-states refused tribute or participation in the alliance and others followed suit, Athenian power steadily declined. Athens looked elsewhere for colonial expansion but, finding few sustainable successes, only weakened further. After the Peloponnesian War ended (404 B.C.E.) and the Athenian fleet was punitively reduced to 12 ships, there is no further record of Athens amassing a fleet in excess of 100 vessels.⁴²⁶ With Sparta not up to the task of maritime defense, a void of seaborne protection developed in the eastern Mediterranean as the semi-dependent Greek city-states became more independent and less willing to

The reality of this situation was far more complex than as summarized here, with different circumstances for each ally, but for the purpose of this dissertation extrapolation is not necessary.

⁴²¹ See Papalas 2000, 387-400.

⁴²² Borza 1987, 33; Meiggs 1982, 131-3; Herod. 7.139.1-4.

⁴²³ Meiggs 1982, 119-30; see also Haas 1985.

⁴²⁴ See *IG* II². 1611; Meiggs 1982, 131; having the materials to build and outfit this many vessels is an issue separate from actually building and sailing them. Meiggs (1982, 131) suggests the lack of a large standing fleet was not for want of wood but rather crew and finances. ⁴²⁵ The reality of this situation was far more complex than as summarized here, with different

⁴²⁶ Meiggs 1982, 131.

protect each other.⁴²⁷ G.L. Cawkwell has, however, argued that based on the amount of equipment held in the naval yards the Athenian navy remained at least adequate through the 360s B.C.E.⁴²⁸

By the time Philip II became king of Macedon in 359 B.C.E., Greece was ripe for a charismatic leader with the ability to unite the poleis. Unification was essentially inevitable with Philip II's defeat of the Athenian and Theban forces at the battle of Chaeronea and the subsequent unification of many of the poleis in the Peloponnese in 338 B.C.E. The following year, Philip II convened a council of the Greek city-states at Corinth, solidifying the union.

Written Record of Ship Timber

Between Meiggs,⁴²⁹ Rackham,⁴³⁰ and Borza,⁴³¹ a holistic understanding of the written record of ship timber and possible methods of acquisitions and management is easily accessible. Firmly grounded in the ancient texts,⁴³² these three authors essentially conclude that there is "only a little evidence" to suggest that an open market in timber existed.⁴³³ Bissa, basing her conclusions primarily on Meiggs' work, offers a reasonable reinterpretation indicating that Classical-period governments

⁴²⁷ For a summary of the balance of sea power in the eastern Mediterranean during the 5th century B.C.E. see Morrison (1995, 49-57).

⁴²⁸ Cawkwell 1984, 334-42.

⁴²⁹ Meiggs 1982, 13-38, 116-140.

⁴³⁰ Rackham 2001, especially 38-9.

⁴³¹ Borza 1987.

⁴³² Meiggs' section on the "Confusion of Species" (1982, 410-22) discusses one of the critical pitfalls in relying on the texts: *kedros*. The same word was used in Latin and Greek for cedar and juniper. This dilemma, however, extends back into at least the ancient Egyptian 4th Dynasty. An ancient text indicates that timbers found in the Bent Pyramid of Snefru at Dahshur should have been cedar, but they are, in fact, juniper (personal communication, Bryant Bannister, 1 December 2009.)

⁴³³ Borza 1987, 51.

intervened in the trade of timber for warships by attempting to control the sources.⁴³⁴ As merchant vessels were owned primarily by citizens, Bissa's conclusions do not extend to merchant ships' timbers. An analysis of the origin of ship timbers should yield a valuable frame of reference from which trade in timber for the construction of merchant ships may be better examined.

Fully understanding the availability and procurement of ship timber in classical Greece requires an understanding of the industries and applications that competed with shipbuilding for wood. Description of those activities lies beyond the scope of this work, but they include the need for large timbers to span temple roofs and other architectural structures such as doors,⁴³⁵ furniture and art,⁴³⁶ firewood,⁴³⁷ tar and pitch,⁴³⁸ and especially charcoal.⁴³⁹ Consumption for military applications outside of those noted directly above should also be considered. The development of large navies in the first quarter of the 5th century B.C.E. exacerbated the need. An anecdote from Thucydides serves to reinforce how important timber was: when the Athenians outside the city were ordered to move inside the walls during the Peloponnesian War, they brought the wooden elements of their homes with them.⁴⁴⁰ This example of reuse may help to explain why so little wood is found in terrestrial excavations, apart from environmental

⁴³⁴ Bissa 2009, 105-52.

⁴³⁵ Borza 1987, n.12; Rackham (2001,35-7) suggests that internal columns in temples, which were often structurally unnecessary, served the purpose of supporting joints in the ceiling and roof timbers; see Meiggs 1982, fig. 7.

⁴³⁶ See Richter 1926; Meiggs 1982, 279-324.

⁴³⁷ Unfortunately, little evidence remains to properly evaluate how "the extremely large demand for fuel" was met (Meiggs 1982, 205).

⁴³⁸ Not only for sealing ships but also as lining for amphorae and probably coating rigging and ropes; see Glotz 1916, 280-90; Connan and Nissenbaum 2003.

 ⁴³⁹ See Rackham 2001, 33-40; Borza 1987; Hughes and Thirgood 1982, 61-5; van Andel et al. 1986; mines alone required an incredible volume of timber for various purposes (Papacostas 2001, 108-28)
⁴⁴⁰ Thuc, 2.14.1.

reasons that are often not conducive to the preservation of plant and other organic remains.

Ancient authors and inscriptions⁴⁴¹ provide data for the reconstruction of a general outline of preferences for ship timbers by geographic location.⁴⁴² From most to least desirable: Macedonia, southern Black Sea (Bythinia, Sinope, and Amisus), Thrace, Thessaly, southern Italy (Sila, Calabria, parts of Campania, and later Sicily), Cilicia, Chalcidice, Euboea, and Boeotia.⁴⁴³ The most desirable sources of timber in the region of Macedonia seem to have remained a royal possession during the Classical period.⁴⁴⁴

These sources also indicate preferences and applications for certain timber species. Fir (*Abies* spp.) was favored for masts and oars, as well as for the hulls of warships,⁴⁴⁵ which required lightweight timber for their speed and maneuverability. If properly shaped while green, such wood will be solid but still retain its spring and was accordingly favored for timbers placed under extreme stresses. However, in Aristophanes' comedy Knights (424 B.C.E., performed in Athens), the triereis (ramming warships)⁴⁴⁶ hold a meeting, in which one ship says to members of the crew, "I, like you, am built of pine..."⁴⁴⁷ Unfortunately, warships are largely absent from the archaeological

⁴⁴¹ See Meiggs 1982, 116-53, 188-217, appendices.

⁴⁴² Especially Herodotus, Plato, Pseudo-Xenophon, Theophrastus, and temple accounts. These ancient sources are well summarized in Meiggs (1982), and need not be repeated here.

⁴⁴³ Especially see Theophr. *Hist. pl.* 4.5.3-6, 5.2.1, 5.8.1-3; Rackham 2001, 34-5.

⁴⁴⁴ Borza 1987, 39, n. 29.

⁴⁴⁵ Meiggs 1982, 118-9; Theophr. *Hist. pl.* 5.6.3-8, 5.7.1-8.; see also Pl. *Leg.* 705c; Diod. Sic. 17.89.4; Verg. Aen. 5.663, 8.91; discussion of why so much timber was needed for oars can be found in Morrison et al. (2000, 240), Bissa (2009, 114), and Borza (1987, 33-4). ⁴⁴⁶ See Coates (1990, 111-6) for a discussion and description of triereis.

⁴⁴⁷ Ar. Eq. 1300-10; cf. Morrison et al. 2000, 179; Theophrastus (Hist. pl. 5.7.13) also confirmed that warships were sometimes made of pine when fir was unavailable.

record, likely due to their light build and the fact that they carried little to no cargo or ballast to weight them down and preserve the remains on the seabed after a wreck.⁴⁴⁸

Pines (*Pinus* spp.) appear to have been the second most desirable timbers and are mentioned as the preferred timber for merchantmen.⁴⁴⁹ A sampling of shipwrecks throughout the Mediterranean confirms that conifers⁴⁵⁰ are most prevalent in hull planking, with pines being the dominant genus.⁴⁵¹ Since the emphasis in constructing a merchant vessel was longevity, conifers proved favorable due to their resins, which deter (but do not prevent) pests and fungi. Pines, probably more widely available than the other species, grow comparatively quickly and straight. Identification of pine species is problematic in the ancient literature, as at least 13 different species grow in the Mediterranean.⁴⁵² Since most pine species today have a small geographic distribution the sourcing of pines, which are well represented in shipwrecks, could be of great utility in determining where shipwrecked timber originated. However, such a task requires reconstructing the ancient distribution of each species.

Cedar (*Cedrus libani*) was, perhaps throughout antiquity in the Mediterranean, another desirable timber. Theophrastus states that it was third in order of preference for

⁴⁴⁸ At least five rams, likely from warships, have been recovered. The Athlit ram (ca. 2nd century B.C.E.) being the first discovered and most thoroughly published, included some timbers: structural timbers of cedar (stem and ramming timber), elm (chock and nosing timbers), and pine (keel, planking, and wales) with oak tenons and pegs (Steffy 1991, 17-39).

⁴⁴⁹ Meiggs 1982, 118; Theophr. *Hist. pl.* 5.6.3-8, 5.7.1-8.; see also Diod. Sic. 17.89.4.

⁴⁵⁰ Conifers include firs, cypresses (*Cupressaceae* spp.), junipers (*Juniperus* spp.), larches (*Larix* spp.), and pines (*Pinus* spp.).

⁴⁵¹ See Guibal and Pomey 2003, 35-41; Fitzgerald 1994, 164-218.

⁴⁵² *Pinus halepensis* (Aleppo pine) was perhaps the most prominent, but *P. nigra*, *P. brutia*, *P. pinaster*, *P. sylvestris* were also common species; see Klaus 1987 for a detailed discussion of Mediterranean pines and their history; Barbéro et al. 1998.

building ships, especially valued for its length and lack of knots,⁴⁵³ but this ranking probably reflects its limited availability rather than its properties. Cedar in classical contexts could have originated in the Taurus Mountains in Cilicia, the Amarus Mountains in Syria, and the Lebanese and Antilebanese Mountains of the Phoenician coast. Pliny makes specific mention of its use in the Temple of Artemis at Ephesus but excavations of that site (which took place in the 19th century) have provided little useful data for comparison.⁴⁵⁴ Most ancient temples, despite their use of timber, yield very little archaeological wood, probably due to repetitive sacking and burning, reuse, and other pilfering: temples were obvious targets for invaders. The longevity and attractive appearance of cedar are two of its desirable traits. The resin in cedar is toxic to most pests, and fungi invade the cells only after the resin has deteriorated, which, under good conditions, can take millennia.

Athenian Acquisition of Ship Timber

The acquisition and sustainability of Athenian timber supplies appear to have been directly linked to the political environment and organization of leadership in the city, and perhaps also to the establishment of the Delian League.⁴⁵⁵ When required or requested, some allies and subject poleis provided entire ships, reducing the need for raw timber⁴⁵⁶ and permitting Athens and/or the league to grow or refurbish the fleet, or obviate the need to maintain a large fleet. If allied poleis could be relied upon for ships

⁴⁵³ Theophr. *Hist. pl.* 5.6.3-8, 5.7.1-8.

⁴⁵⁴ Plin. NH 35.21.95.

⁴⁵⁵ As indicated by Pseudo-Xenophon (*Ath. Pol.* 2.11-12); see also Meiggs 1982, 188-217; Meiggs revisited see Bissa (2009, 117-40).

⁴⁵⁶ For example, see Meritt et al. (1950, 321).

and support when needed, Athens could direct its own resources elsewhere. For example: Samian vessels were "dutifully provided" for the Athenian war in Egypt during 460-454; more than 30 Lesbian ships were sent to aid in the suppression of the revolt of Samos in 440/439; Chios provided vessels during much of the Peloponnesian War.⁴⁵⁷ Since few of the desirable timber species were available in Attica,⁴⁵⁸ and none apparently in the quantities necessary for the construction of large fleets, Athens needed to draw from sources beyond its local environment. These could have been in the form of "tribute" to Athena by members of the Delian League.⁴⁵⁹

It is likely that Athens encouraged allies to commute their tribute payments from ships to silver.⁴⁶⁰ When a ship and crew is not engaged, the expense is disproportionate to the benefit. Ships are expensive to outfit, crew, and maintain, and silver could be used to purchase materials and train crew among other things.⁴⁶¹ When Athens was strong other options for obtaining ships existed, including confiscation, as happened to many fleets, for example the Mytileneans in 427 B.C.E., and conscription. Many poleis in the Delian League appear to have been required, encouraged, or permitted to maintain small fleets for their own defense. If members of the Delian League were in trouble, the Athenian fleet could be sent to supplement the local force.⁴⁶² Additionally, the logistics

⁴⁵⁷ Samos: Quinn 1981, 10; Lesbos: Quinn 1981, 24; Chios: Quinn 1981, 40; see also Thuc. 1.116.2, 2.9.5, 56.2, 6.31.2; Diod. Sic. 12.27.4, 28.2.

⁴⁵⁸ For example see Plato's description of the deforestation near Athens (*Criti.* 111b-d); See also Hughes (1983) for a summary.

⁴⁵⁹ See Meritt et al. 1950; Meiggs 1973; see also Meiggs and Lewis 1999, 23, 25, 34, 67, 77, 78, 80, 91, 94.

⁴⁶⁰ With the possible exception of oars, which were perhaps the most difficult ship timbers to obtain. Tribute in quality oars, or timber that could be used for oars is not likely to have been refused.

⁴⁶¹ Meiggs (1982, 131) suggests crew and finances were more difficult to obtain than ships, or at least the materials to build ships.

⁴⁶² Quinn 1981, 36, 40-2, 53-4.

of coordinating multiple ships, crews, and commanders with different levels of experience, training, and likely even speaking different dialects must have been a compelling factor in disbanding the fleet when not in need.

The Ahiqar Scroll provides contemporary evidence useful for the movement of timber between Phoenicia and Egypt. This palimpsest from Elephantine Island in Upper Egypt, dating to the "eleventh year of the reign of Xerxes," 475 B.C.E., provides an example of ship timber traded⁴⁶³ and taxed at an unnamed Egyptian port.⁴⁶⁴ The costs varied by size of ship and origin, with the Ionians bearing a larger expense than their Phoenician counterparts. Timber duties included: an old oar/rudder, new oars, and several indeterminate categories of boards (possibly beams and planks).⁴⁶⁵ Athens *could* have required similar taxes or tributes, but it does not seem likely.

Xenophon,⁴⁶⁶ Thucydides,⁴⁶⁷ and Theophrastus⁴⁶⁸ generally agree that Athens, being short of timber locally, turned primarily to Macedonia, Thrace, and Chalcidice when politically feasible, and scoured neighboring Euboea or Boeotia when necessary.⁴⁶⁹ When Athens was in conflict with one region of supply, it would turn to another. In the second half of the 5th century Athens founded a colony at Amphipolis, situated at the crossroads of Macedon, Thrace, and Chalcidice. The foundation

⁴⁶³ The only export noted was natron (Yardeni 1994, 68-71); see Shortland et al. (2006) for a description of natron, its uses, and sources.

⁴⁶⁴ The need for and application of these timbers can probably be paralleled by contemporary boat repair documents, also from Elephantine (Stieglitz 2004; the Crowley 26 manuscript, dating to 411 B.C.E [see Steiner 2006, 641-85]).

⁴⁶⁵ Yardeni 1994, 70.

⁴⁶⁶ Xen. *Hell*. 1.1.22-27.

⁴⁶⁷ Thuc. 4. 108. 1; cf. Herod. 5.23.2.

⁴⁶⁸ Theophr. *Hist. pl.* 4.5.3-6, 5.2.1, 5.8.1-3.

⁴⁶⁹ See Borza (1987) for a thorough discussion of Macedonian/Athenian timber as related to politics; Thucydides (8. 96. 2) remarks that "after Athens was defeated by the Spartans off Eritrea, Euboea was more important to Athens that Attica" because of its timber stores (Meiggs 1982, 209).

corresponded to a period during which Macedon and Athens were not on good terms. Unfortunately for Athens, the colony, situated too close to the peraia of Thasos, was destroyed after only 12 years,⁴⁷⁰ a loss that dealt a "fatal" blow to Athens and its timber supply.⁴⁷¹

The importance of quality timbers for critical elements of construction and equipment (oars, masts, and keels especially⁴⁷²) is underscored by the special treatment of people who provided such resources. The Phanosthenes Decree from the late 5th century B.C. E. provides a prime example.⁴⁷³ Athenian citizens Phanosthenes, Antiochides, and their associates were granted honors for importing ships' oars. In times of great timber need Macedonians -- Alexander I in about 480 B.C.E. and Archelaus I in 407 B.C.E. -- were honored for their contributions to Athenian naval timber stores.⁴⁷⁴

With animosity toward Athens growing in the Aegean, especially among other Delian League members in the late 5th century, it should come as no surprise that points west, such as Italy, became more prominent in inscriptions. By 415 B.C. E., Athenian general Alcibiades was pressing the city to send an expedition to Sicily because it was a significant source of ship timber, as well as grain.⁴⁷⁵ The Athenian fleet was soundly defeated at Syracuse two years later, perhaps in part because they had difficulty

⁴⁷⁰ In his role as an Athenian general, Thucydides was ostracized for arriving too late to defend the colony at Amphipolis, as he was tasked, against the Spartan attack in 424 B.C.E. (Richard 2003, 86).

⁴⁷¹ Meritt et al. 1950, 309.

⁴⁷² For example, see Herod. 5.23.

⁴⁷³ Walbank 1976; MacDonald 1981.

⁴⁷⁴ *IG* I², 105; see also Meritt et al. 1950, 325, n. 106; Herod. 8.136.1; cf. Borza 1987, 41. There is some concern as to whether Macedon could have provided timber in the early 5th century B.C.E.: see Bissa (2009, 117-8) and Borza (1987, 41-2). ⁴⁷⁵ Thuc. 6.90.3.

obtaining suitable ship timber.⁴⁷⁶ Soon afterward, the Peloponnesian War came to an end and Athenian superiority along with it.

Ship Timber

Despite the fact that hundreds or perhaps even thousands of Athenian ships, and hundreds more vessels from other poleis, plied the Mediterranean, well-excavated classical Greek hull remains are virtually absent from the existing archaeological record. Ships were wrecked often, as evidenced by the presence of amphora mounds on the sea bottom. A similarly unknown but likely great number of ships were destroyed during war but have apparently not been preserved. Estimates based on contemporary documents suggest that perhaps as many as 1,500 Greek triremes alone were built between 482 and 404 B.C.E.⁴⁷⁷ The total figure of seagoing vessels built in the eastern Mediterranean during this period must be substantially higher. With increased maritime traffic certainly came an increase in the number of wrecks.

At least 70 shipwreck sites in the Mediterranean are suspected to be classical in date and *possibly* include timber remains.⁴⁷⁸ The majority and perhaps all of these sites represent merchant vessels. Of these 70 possible sites, only a single one has extensive hull remains that have been preserved, studied, and published: Ma'agan Mikhael,

⁴⁷⁶ Thuc. 8.1.3.

⁴⁷⁷ Borza 1987, 34; I believe this estimate to be too high and a better figure lies closer to 1,000.

⁴⁷⁸ Compiled primarily from Parker (1992, inventory numbers 13, 19, 58, 75, 83, 128, 145, 191, 205, 217, 223, 237, 313, 355, 431, 434, 440, 527, 539, 541, 545, 550, 552, 562, 595, 612, 674, 677, 729, 737, 739, 756, 793, 808, 809, 820, 839, 870, 879, 895, 915, 922, 971, 983, 1006, 1058, 1078, 1081, 1091, 1095, 1107, 1127, 1144, 1155, 1187, 1190, 1228); there are certainly more sites. Many formal and informal underwater surveys have been carried out in the eastern Mediterranean, notably by the Institute of Nautical Archaeology.

Israel.⁴⁷⁹ Indeed, one of the motivating factors in the recent excavation of the shipwreck at Tektaş Burnu, Turkey (ca. 440-425 B.C.E.), was the expectation that hull remains might be recovered.⁴⁸⁰ Unfortunately, the site was not as expected: no substantial hull remains or evidence of the ship's other wooden structures were found.⁴⁸¹ Other Classical shipwrecks have been wholly or partly excavated but to date have revealed equally little regarding their timbers, including those at Gela 2 (ca. 475 B.C.E.),⁴⁸² Phagrou (ca. 475-425 B.C.E.),⁴⁸³ Alonnesos (ca. 420-400 B.C.E.),⁴⁸⁴ and Porticello (ca. 399-385 B.C.E.).⁴⁸⁵ The Mataria boat from Cairo (ca. 400 B.C.E.) will also be considered as it derives from the period and has extensive hull remains, but it has not been well studied and may be Egyptian, Persian, Greek, or even Roman in origin.⁴⁸⁶ At least six other unexplored sites also hold great potential.⁴⁸⁷

At least three methods of ancient shipbuilding are evident in the Mediterranean:

sewn, pegged mortise-and-tenon, and nailed. The Classical period appears to have been

http://news.nationalgeographic. com/news/2008/08/080811-greek-ship.html).

⁴⁸⁶ Ward 2000, 129-35.

⁴⁷⁹ The origin of the ship is not clear, but sourcing its timbers, as described in Chapter III, could help resolve this issue.

⁴⁸⁰ Carlson 2003, 581-2.

⁴⁸¹ Carlson 2003, 595; again, this underscores the role of site formation processes in the recovery and interpretation of ship timbers.

⁴⁸² This wreck offered substantial timber remains, but the hull was flattened by more than 20 tons of ballast. Initially the hull was recorded but not excavated (Benini 2001, 97-106). However, in late 2008 the vessel was recovered and is now in conservation (Valsecchi 2008, 11 August,

⁴⁸³ The investigation consisted of only a 2 x 2 m exploratory grid, see Touchais (1996); Kazianes 1996. Apparently further excavation has not been conducted (Foley et al. 2009, 291).

⁴⁸⁴ This vessel is perhaps the most promising but also incredibly daunting, with its cargo of more than 4,000 amphorae. Only two units, 2 x 2 m each, were excavated, and in one a significant amount of charcoal was discovered along with "chunks of unburned wood" (Hadjidaki 1996, 575). To the best of my knowledge, the wood was not sampled or in any other way analyzed.

⁴⁸⁵ Also known as the Straits of Messina wreck; see Lawall (1998) for a discussion of the date. The site was heavily looted when excavated in 1970 and yielded a total of less than 1/3 cubic meter of wood (Eisman and Ridgway 1987, 10-6). The two applicable radiocarbon samples seem to indicate the vessel was of some age when it sank, which corresponds well with the lead repair patches also recovered (Eisman and Ridgway 1987, 11-6, 24, table 1).

⁴⁸⁷ Five sites are described by Carlson (2004, 138-42), and the Mazotos wreck (Demesticha forthcoming).

the crossroads of these trends. Whether these differences are representative of temporal, geographic, or other factors is not yet agreed upon.⁴⁸⁸ Regardless, philosophically these traditions are very different⁴⁸⁹ and accordingly have implications for the cultural interpretation of timber. These philosophical differences are manifest in the ship timbers and offer opportunities for analysis, including differences in the shape(s) of internal framing members.

It seems that most of the 6th century B.C.E. sewn ships are Aegean or eastern Greek in origin regardless of where in the Mediterranean they sank.⁴⁹⁰ Frames of sewn vessels remain rounded at their tops⁴⁹¹ to reduce or more evenly distribute friction on the cordage. Coincidentally, there is a greater likelihood of the outermost growth rings remaining on these frames because the timbers more closely follow the original shape of the trees from which they were harvested and fashioned. The outer rings can be of great utility for analysis, as described in Chapter III.

In vessels built with pegged mortise-and-tenon or nailed methods, typically of classical or Hellenistic date, such as the later Kyrenia wreck,⁴⁹² the tops and sides of frames are squared, which provides a better surface on which to clench the nails. Such modified timbers are more likely than rounded frames to retain evidence of tool marks, because more labor is required to bring squared timber to form.

⁴⁸⁸ See McCarthy (2005) for a summary of ships' fastenings.

⁴⁸⁹ See Steffy 1994, 23-78.

⁴⁹⁰ For example wrecks from: Pabuç Burnu, Bon Porté, Jules-Verne 7 and 9, Gela 1 and 2, Ma'agan Mikhael; see Polzer 2004, 8; The ships were possibly built by Greeks in the eastern Mediterranean or, perhaps more likely, built by Greek shipwrights elsewhere in the Mediterranean. An investigation of their timbers as proposed in Chapter III of this dissertation should be able to address the question of origin. ⁴⁹¹ For example wrecks from: Bon Porté, Jules-Verne 7 and 9, Gela 1, and Ma'agan Mikhael.

⁴⁹² Steffy 1985; likely also the Porticello wreck.

Another construction trend that likely affects timber usage evidenced during the Classical period is an increasing frequency of frames placed closer to one another.⁴⁹³ An increased use of frames required more curved timber, adaptation of construction methods, or both. An increased need for curved timbers would then require that the shipwright "take advantage of a wider variety of timber shapes"⁴⁹⁴ than those primarily employed in edge joinery. The use of such curved timbers, may have encouraged the development of wineglass-shaped hulls,⁴⁹⁵ which appear to become prominent during the late Archaic or Classical period,⁴⁹⁶ and more pronounced over time.⁴⁹⁷ However, it is equally possible that the desire for wineglass-shaped hulls was the driving factor in making greater use of curved timbers.

It is not the intent of this work to debate the above trends or methods, only to indicate that construction method and philosophy affect opportunities for interpreting cultural information from ship timbers.

Tool Marks

It is likely that the Greek shipbuilders' tool kit closely resembled that of the ancient Egyptians, discussed in Chapter IV. However, terrestrial excavations reveal that

⁴⁹³ See Steffy 1994, 23-78; The following figures are evidence for decreasing rooms/closer spacing of frames (from Kahanov 2004, table 9): Bon Porté wreck, 90 cm; Jules-Verne 9 wreck, 96 cm; Jules-Verne 7 wreck, 98 cm; César 1 wreck, 90 cm; Gela 1 wreck, 84 cm; Gela 2 wreck, 70; Ma'agan Mikhael wreck, 75 cm; Kyrenia ship, 25 cm.

⁴⁹⁴ As Mark (2005, 65) states: the system of "closely spaced floor timbers with unattached futtocks alternating with half-frames, was a simpler and stronger system [than sewing] that took advantage of a wider variety of timber shapes."

⁴⁹⁵ As the carved floor timbers of the Ma'agan Mikhael wreck seem to indicate.

⁴⁹⁶ For example the wrecks from: Gela 2, Ma'agan Mikhael, and Kyrenia

⁴⁹⁷ Steffy 1994, 23-78; Mark 2005, 48.

at least two additional tools were available to the Greeks: the rule and the plane.⁴⁹⁸ In addition to the availability of iron blades, which certainly kept a sharp edge longer than copper alloy, the tools available to the Greeks were improved in form (Fig. 17). Sometime between 500 and 200 B.C.E. the axe assumed a more efficient form that is familiar today.⁴⁹⁹



Figure 17. A late 6th or early 5th century ceramic vessel. Greek carpenter with an adze, likely stylized (from Goodman 1976, fig. 10; original copyright Trustees of the British Museum).

 ⁴⁹⁸ Goodman 1976, 9 table 1; a ruler was found with the Ma'agan Mikhael wreck (Mor 2004, 172 fig. 18.)
⁴⁹⁹ Goodman 1976, 23.

The tool mark analysis of the Ma'agan Mikhael wreck, as discussed in Chapter III, is the only such study for this period. The Mataria boat, with significant hull planking remains, would be an ideal candidate for investigation of tool marks, but this aspect was apparently not studied by its excavators or conservators. Subsequent conservation efforts, described by Ward,⁵⁰⁰ are likely to have jeopardized the possibility of extracting such information in the future.

Assembly and Construction Marks

Three forms of scribe marks were found on the Ma'agan Mikhael wreck: "X" marks, frame position marks, and scarf alignment marks.⁵⁰¹ The X marks were found on the primary structural members, especially the keel, stem, and hull planks. These marks were used to indicate the exact location of the timbers in relation to one another for ease of assembly (Fig. 18). Frame position marks were lines incised on hull plank interiors adjacent to nails used to align the framing members so that they could then be secured. Based on the prevalence of marks but absence of a discernable pattern among them, Mor suggests that the frames were removed and replaced several times before finding their final locations.⁵⁰² In at least one instance, inscribed lines were made to aid in the joining of two timbers in a scarf. Most of these marks were removed during the finishing phase, further inhibiting our ability to better understand the construction process.

⁵⁰⁰ Ward 2000, 128-31.

⁵⁰¹ All information on the Ma'agan Mikhael wreck's timber marks comes from Mor (2004, 167-8).

⁵⁰² Mor 2004, 168.



Figure 18. X mark on the keel of the Ma'agan Mikhael shipwreck (from Mor 2004, 167 fig.7; photograph by J.J. Gottlieb).

The Mataria boat has either Greek or demotic Egyptian letters, categorized as graffiti, carved deeply into at least one plank.⁵⁰³ With little comparative material and an incomplete analysis of the hull these marks cannot be fully understood. Categorizing the marks as graffiti is not an unreasonable conclusion, but the identification certainly merits further investigation. The painted letters on the Marsala Punic wreck, as discussed in

⁵⁰³ Ward 2000, 133, fig. 76.

Chapter III, provide the closest material for comparison.⁵⁰⁴ However, the Mataria boat markings appear to be an isolated incident and not indicative of assembly.

Timber Size and Shape

The builders of the Ma'agan Mikhael ship obtained sufficient quantities of quality timber.⁵⁰⁵ Nevertheless, the builder or supplier made economically sound decisions in preparing the wood, including halving logs to maximize the number of planks. Trees with straight trunks were chosen for the hull planks and sawn near their middle. This has the mechanical effect of reducing bowing as well. The tall trees necessary to produce these timbers combined with a significantly higher frequency of knots corresponding to the tops of these trees implies they were harvested from a dense forest. Such an environment encourages quick and straight growth as the tree competes for sunlight in the canopy: the shipbuilder or timber supplier must have known this. That large knots were also relegated to the width of the plank rather than interior or exterior faces demonstrates considerable foresight; knots in pine are prone to shrink and fall out over time. Framing timbers were selected from trees "characterized by free growth"⁵⁰⁶ which encouraged the shapes needed to guide the curves of the vessel. Some frames even retained bark. Ironically, the Ma'agan Mikhael ship was presumably constructed for a long career but was lost early, perhaps even on its maiden voyage.

⁵⁰⁴ Frost 1973, 33.

⁵⁰⁵ Hillman and Liphschitz's (2004, especially 145-50) extremely thorough analysis of the timbers is a model for future investigations and forms the basis for information presented here.

⁵⁰⁶ Hillman and Liphschitz 2004, 148.

Species Identification and Use

Species identifications of the timbers from the ships discussed above indicate a preference for pines (*Pinus* spp.) in merchant vessels (Table 2), as suggested by textual references. Few other species are attested to in classical ship construction, but some correlations can be drawn. Hull planks tend to be of resinous woods, primarily pines. Components responsible for structural integrity, including frames, tenons, and pegs, tend to be hardwoods, often oak. These correlations should be interpreted with caution, as the sample set is not very large and the typically fragmentary condition of classical ship remains often prevents determination of the precise use or location in the hull of the identified timber.⁵⁰⁷

Site	Hull	Frames	Tenons / Pegs	Other
Gela 2	Pinus sp.	Quercus sp.	Quercus sp.	Acer sp.
Tektaş Burnu	<i>Pinus</i> sp. and/or <i>Quercus</i> sp.	<i>Quercus</i> sp. and/or <i>Pinus</i> sp.	Likely Quercus sp.	<i>Ulmus</i> sp.
Ma'agan Mikhael	Pinus brutia	Pinus brutia	<i>Quercus coccifera,</i> <i>Fagus</i> sp.	Quercus spp., Fraxinus excelsior, Phragmites communis, Arundo donax
Porticello	Pinus sp.	?	?	
Mataria	Ficus sycomorus	?	Ziziphus sp.	

Table 2. Condensed timber species and uses (see Appendix).

⁵⁰⁷ Tektaş Burnu is an excellent example, see Jurgens et al. (2003, 400).

The varying levels of degradation in the Tektaş Burnu wood remains are also important to consider when considering the ancient shipbuilders' choice of timbers, at they reflect the literary sources noted above. Analysis of wood decay in this vessel confirms greater longevity of pines compared to that of oaks:

"Evidence of marine borers and extensive decay was present in all samples, with oak exhibiting the greatest alteration to its anatomy, and the pine showing the least."⁵⁰⁸

Meiggs suggest that the importance of speed in the ancient Mediterranean is a reason for the regular reliance on conifers in watercraft.⁵⁰⁹ A lighter vessel could be propelled at greater speeds, and pine and fir are substantially lighter than oak. Speed would have been an important consideration especially for ships under oar, namely, military vessels⁵¹⁰ and merchant ships carrying perishable contents. It was likely also a necessity of all ships to deter pirates and other enemies at sea.⁵¹¹

Summary

Surprisingly, classical shipwrecks have not yet produced any evidence for the use of fir or cedar, two of the three preferred woods repeatedly noted by classical authors. The use of pine in hulls and oak, or at least hardwoods, in structural members is,

⁵⁰⁸ Jurgens et al. 2003, 402.

⁵⁰⁹ Meiggs 1982, 118 n. 4.

⁵¹⁰ See Strauss (2000) and Whitehead (1987) for naval tactics and the need for speed.

⁵¹¹ Mark (2005, 17-24) discusses this concept at some length. Though relative to the Dark Ages and Homer's epics, the general concept probably still applied in the Classical period: sailors were opportunistic.

however, expected. Even so, insufficient wood has been recovered or studied in order to attempt to source it or to attempt most other cultural analyses. It should be kept in mind; however, that absence of evidence is not necessarily evidence of absence. What ship timber can tell us about people in the Classical period remains to be seen, despite intriguing glimpses mentioned above.

Given the rich textual records for the period, it is expected that these sources could be much better evaluated by archaeological investigation, but this will require further excavations yielding more ship timber. The recent recovery of the Gela 2 wreck is encouraging, as was the excavation of the wreck at Tektaş Burnu. The Alonnesos wreck appears to hold great potential for extant timber, but its cargo of 4,000 or more amphorae poses an intimidating prospect for any potential excavator.

J. Richard Steffy's words are as true today as they were when published 16 years ago and similarly apply to understanding ship timber from the Classical period:

"Unfortunately, archaeology has not yet provided a clear picture of Mediterranean seagoing ships until late in the Greek period. There are plenty of illustrations and there is later literary evidence to whet our appetites."⁵¹²

This case study provides an important lesson: even when a rich textual record exists it is the physical evidence of the timbers themselves that is needed to extract quality objective information. No amount of written records can compensate for a lack of timber when addressing the questions posed in this dissertation.

⁵¹² Steffy 1994, 39.

CHAPTER VI

PORTUGAL AND THE IBERIAN PENINSULA DURING THE DISCOVERIES

During the 15th and 16th centuries C.E., increased sociopolitical organization in the Iberian regions of Aragon, Castile, Leon, Navarre, and Portugal significantly contributed to propelling Europe out of the Medieval Period.⁵¹³ As early agents in the development of modern Europe, the communities were well positioned to prosper. Those with significant coastal enterprises, in which prosperity intertwined with maritime expansion, discoveries, and trade, benefitted most. Social, political, and economic development in the Iberian Peninsula during the Age of Discovery was driven by success on the seas, carried in wooden ships.

Social, Political, and Economic Circumstances

Portugal, with a maritime history out of proportion to its terrestrial size,⁵¹⁴ is the primary focus of this chapter.⁵¹⁵ Early maritime expeditions were launched in the late 13th and early 14th century by the Burgundian sovereigns of Portugal, were continued into the second dynasty, under king João I (reign: 1385-1433 C.E.),⁵¹⁶ and championed by his son Duarte, who succeeded him on the throne, and Henrique (Prince Henry the Navigator, born: 1394, died: 1460), who was granted the royal monopoly to the

⁵¹³ See Bethencourt and Curto 2007, 1-18; Newitt 2005, 1-35; Russell 1995; Braudel 1995.

⁵¹⁴ Barker 2001, 213.

⁵¹⁵ For more thorough studies of the economy of the Portuguese empire, see Schwartz 2007, 19-48; Braudel 1995, 355-95, 418-604; Boyajian 1993; Boxer 1969, 1984.

⁵¹⁶ For more information, see Sergio et al. 1949.

commerce and exploration of the Atlantic.⁵¹⁷ The 15th century was marked by regular progress in expanding the borders of the European world's map and discovering new economic opportunities, beginning with the expulsion of the Moors and conquest of Ceuta in North Africa, in 1415.⁵¹⁸ The "discovery" of western coastal Africa was marked by a series of notable checkpoints: rediscovery of Madeira ca. 1420, the Azores ca. 1430, Cape Verde ca. 1460, and the Cape of Good Hope in late 1487. Soon thereafter, in 1498, Vasco da Gama reached India, opening a lucrative maritime trade route.⁵¹⁹ The Portuguese-led discoveries reached their seafaring apex with the circumnavigation of the globe by Ferdinand Magellan's expedition of 1519-1522, although working for the Spanish crown.⁵²⁰

During the 16th century, Portugal was the center of a trading network that spanned Newfoundland, Brazil, both coasts of Africa, India, Indonesia, China, and Japan. Lisbon also functioned as the center of a redistributive network, because all of their colonial goods could not be consumed at home. The Portuguese even managed to become social and economic intermediaries between cultures in the Far East.⁵²¹ Traders from all over Europe and the Mediterranean eventually found their way to Lisbon.

By the middle of the 16th century, Portugal and its representatives overseas dominated more of the maritime world and its trade than anyone else in Europe.

⁵¹⁷ See Sanceau 1969; Russell 1995, XI-XVII.

⁵¹⁸ Newitt 2005, 1; Santos 2002.

⁵¹⁹ Dates are compiled from several sources that do not always agree and are thus approximate, including: Bethencourt and Curto 2007; Castro 2005; Braudel 1995; Boxer 1969.

⁵²⁰ See Cachey (1995) for an English account of Magellan's expedition as recorded by the Italian traveler Antonio Pigafetta. Pigafetta was one of fewer than 20 men (out of some 250 who started the voyage) to complete the first circumnavigation.

⁵²¹ Castro 2005, 12.

Throughout its dominance, the Portuguese crown held a monopoly on major trade within their sphere of influence, including control of the most desired colonial commodities in Europe, such as pepper, cloves, and cinnamon. Heavily susceptible to corruption at both ends of the trade, the monopolies collected large sums of money nonetheless. The operative arm of the crown in Lisbon, the primary economic hub of Portugal, was the *Casa de Índia*, or India House.⁵²² The India House, located in Lisbon's *Praça do Comércio* was essentially a customs house that collected tax, generally 30 percent, on colonial goods entering the city, and determined both war and trade strategies for the Indian and Pacific Oceans. By 1580, the Portuguese had over 50 trading posts from Madeira to Japan, maintained by a native population that high estimates suggest did not exceed 1,500,000 persons.⁵²³

Soon after the India House was established, Spain instituted its own "House of Trade," the *Casa de Contratacion*, but at a lower rate of 20 percent, the "*quinto*". In theory, no Spaniard could sail without the approval of the House of Trade, but corruption and smuggling were common here too. By 1550, privately owned Spanish New World fleets were returning under the protection of state-supported guard ships. In practice, Lisbon was the primary East Indies port for the Portuguese, just as Seville was the Spanish port for the New World, a burgeoning market under Philip II (reign: 1554-1598; also known as Philip I of Portugal).⁵²⁴

⁵²² Unfortunately, an earthquake in 1755 destroyed the India House and nearly all of its records, which would have yielded a wealth of related information; Boxer 1969, 34-40.

⁵²³ Boxer 1969, 11-49.

⁵²⁴ Braudel 1995, 476-80.

The death of Cardinal Henrique in 1580, king since 1578, marked both the end of the Aviz Dynasty in Portugal, which had ruled since 1385, and the beginning of the union of the Iberian crowns by Spanish Hapsburg king Philip II. A shift in policy accompanied Philip II's ascension: until this time Portuguese sea-trade was predominantly guided by royal monopoly. After 1580, many of these businesses were regulated to become formally accessible to private investors.⁵²⁵ Together with the pressures brought about by the Spanish religious wars, the loosening of royal power in Lisbon – governed by a viceroy not always respected by the local merchant class – triggered a growth in the size of ships and a certain disarray in the organization of the voyages that resulted in more shipwrecks. There were signs that the timber supplies around Lisbon were exhausted, partly due to the growing needs of charcoal, and timber for house building and other uses.⁵²⁶ Larger vessels built with smaller and low quality timbers were probably less seaworthy. Shipwrecks in the India Route increased in the period between 1580 and 1620, probably due in part to these causes.

Historical Record of Ship Timber

The concept of tree management, which was apparently not yet concerned with entire forest ecosystems, begins no later than the late Middle Ages in the Iberian Peninsula. The Basque *fueros* ("provincial laws") included timber laws, some as specific as stating that anyone who cuts down an oak is required to plant two saplings.⁵²⁷

⁵²⁵ Castro 2005, 13.

⁵²⁶ Oliveira 1991, 63, 141; Castro 2005, 48;

⁵²⁷ The fueros were first printed in 1527, under the auspices of a commission appointed by Charles V (Knight 1854, 919); See Strong 1893, 317-34; Heiberg 1989, 1-44.

Similarly, it is also believed that in the 14th century king Dinis of Portugal (reign: 1279-1325) had the pine forests of Leiria District planted and kept specifically for shipbuilding purposes and ordered that "cork oaks may not be harmed."⁵²⁸

Fully understanding the availability and procurement of ship timber in Portugal requires an understanding of the procurement of firewood. Firewood was needed in such large quantities by the 16th century C.E. that Barker considers it a "crop."⁵²⁹ Oaks were preferred for firewood and shipbuilding, putting the two in direct competition. It is possible that this relationship not only did not harm or otherwise impede shipbuilding, but may have increased the quality of the oak timbers. Barker builds a strong case that suggests oak trees intended for ship timber were regularly pruned to provide fuel, and that this process simultaneous guided timber shape and increased the density of the heartwood.530

Initially, the ideal of timber conservation appears to be motivated by financial considerations. Casado Soto and Barkham reveal that in 16th century Spanish subsidies for growing oaks were linked to shipbuilding bounties since at least the union of the Basque and Castile territories in the 13th century.⁵³¹ In the 15th century the Spanish followed the Portuguese practice of providing subsidies to owners of timber plantations

 ⁵²⁸ Boxer 1969, 56; Barker 2001, 223.
⁵²⁹ Barker 1998, 223.

⁵³⁰ Barker 1998, 223; Barker concedes that more work is needed to bolster the case for increasing density, perhaps as much as 15 percent, and does not necessarily consider that the cause and effect are directly linked.

⁵³¹ Barkham 1981, 19-24; Barkham 1985; Casado Soto 2001, 131-61; see also Artíñano y de Galdácano 1920.

within a certain distance (three leagues⁵³²) of the sea if they would simply follow regulations aimed at preserving the oak stands. Around 1560, the subsidies were expanded to include municipalities, not just individuals. From these records we can understand that the shipbuilding timbers then likely came from plantations or managed forests, not just wild forest stands. Evidence for such practices should be manifested in the timbers themselves.

In an apparent response to inadequate results from the subsidies mentioned above, the 16th century saw a number of legal regulations aimed at conserving timber stands. Around 1546 king João III (reign: 1521-1557) made cork export a royal monopoly and prohibited cutting it "at its foot" (to encourage coppicing?). Barker has extrapolated from this the suggestion that pruning for fuel was acceptable as long as the bulk of the tree could be used when needed.⁵³³ Costa interpreted this ruling differently, stating that the 1546 prohibition was in reference to all cutting of oaks in the Ribatejo region (Fig. 19).⁵³⁴

⁵³² I am unsure which *lêgua* was used. At least three different *lêgua* are known, roughly corresponding to

^{6,172} m, 5,555 m, and 4,444 m. ⁵³³ Barker 2001, 223.

⁵³⁴ Costa 1997, 316.


Figure 19. Extant Portuguese cork oak (Quercus suber), harvested for cork (Author).

The frequency of ship timber litigation rises in the middle of the 16th century, as Barkham has traced in the Basque region.⁵³⁵ Major legal and contractual changes occur at the end of the century. Philip II removed taxes on ships, probably for a number of reasons, possibly including high timber prices, but the competing Dutch maritime enterprise must be kept in mind.⁵³⁶ Shortly before Philip's death, a number of contracts securing timber for Seville from Poland and Northern Europe probably indicated a lack of suitable Iberian timber for shipbuilding.⁵³⁷ If timber was being imported, dendrochronology and dendroprovenancing should be able to expose the practice, as sufficient chronologies from Northern Europe currently exist.

Ship Timber

Despite that hundreds of Portuguese ships, and hundreds more Spanish and Basque vessels, from the period plied the oceans, well excavated hull remains are the exception.⁵³⁸ This is not due to some miraculous rate of survival or superior seafaring ability. Ships wrecked often. Documents and accounts suggest that perhaps as many as 250 Portuguese India Route ships wrecked from 1498 to 1640,⁵³⁹ but most were salvaged.⁵⁴⁰ At least 75 shipwrecks reasonably suspected to be of the Iberian-tradition

⁵³⁵ Barkham 1981, 19-24.

⁵³⁶ See Boxer 1965; van Duivenvoorde 2008.

⁵³⁷ Braudel 1995, 143.

⁵³⁸ By 1554, the Portuguese were said to have a standing fleet of 200 vessels (Barker 2001, 215). It is not clear if this figure includes the many private ships and traders. Regardless, the estimate is an impressive figure. Similarly, Philip II's Armada included at least 125 ships in 1588 (Martin and Parker 1988, 23), although these were very likely conscripted, purchased and otherwise amassed from all corners of his kingdom.

⁵³⁹ 250 was, however, a small percentage of the total ships and voyages involved.

⁵⁴⁰ Once located, anything that could be salvaged likely was and the ships were often burned to aid recovery of the expensive metal fastenings (see Castro and Thomas forthcoming).

worldwide dating from the 14th to the 17th centuries have been located, and of these 36 are *likely* Portuguese.⁵⁴¹ However, as Castro has concisely noted, little remains of these ships:

"Victims of the international market of antiquities, most Iberian shipwrecks have been destroyed by treasure hunters who abandoned the remains of the hulls after stripping the wreck of all artifacts with market value. Both the artifacts without high monetary value (but with significant academic value) and the hull remains are destroyed in the process."⁵⁴²

Of the 36 ships identified as likely of Portuguese origin, only 5 have sufficient hull remains that have been preserved, studied, and published well enough to contribute to this study. To compile these few vessels some liberty must be taken with the range of dates under study and include wrecks from Corpo Santo, ca. 1390;⁵⁴³ Ria de Aveiro A, ca.1440;⁵⁴⁴ Cais do Sodré, ca. 1475;⁵⁴⁵ Oranjemund, ca. 1530;⁵⁴⁶ *Nossa Senhora dos Mártires* (the Pepper Wreck), 1606.⁵⁴⁷

 ⁵⁴¹ Expanded from Castro 2008, tables 1-6; see also Castro and Thomas forthcoming, tables 2-7.
 ⁵⁴² Castro 2008, 15.

⁵⁴³ The remains are exceptionally scarce and consist of only ten pieces from the stern. None of the timbers are complete and all are broken (Alves et al. 2001a, 405-10).

⁵⁴⁴ Alves et al. 2001c; Alves and Rieth 2005.

⁵⁴⁵ Rodrigues et al. 2001; Castro 2002.

⁵⁴⁶ This wreck was recently excavated; therefore, little analysis is currently available, but it is included here as more is expected soon. Where information is published or otherwise reliable it is included below. Further study of the ship timbers is likely to yield valuable information; see Alves 2009; Castro and Thomas forthcoming.

⁵⁴⁷ Castro 2005.

It is possible that the Arade 1 shipwreck also dates to the late 16th century,⁵⁴⁸ but recent radiocarbon dating places it outside the scope of this work, with a date near the middle of the 17th century.⁵⁴⁹ The Arade 1 ship's timbers hold great potential for cultural interpretation, as it has comparatively good preservation and includes timbers with bark still attached,⁵⁵⁰ which is critical for many lines of investigation.⁵⁵¹ As the date is unclear, the Arade 1 wreck will be included only for comparative purposes when discussing species and use.

While excavated, studied, and preserved shipwrecks from the 16th century are in short supply, there is additional evidence from the period: timbers found at Praça do Município, Lisbon.⁵⁵² It is suggested that the finds represent timber storage or a warehouse for the royal shipyard (*Ribeira das Naus*), established nearby in 1515 (Fig. 20).⁵⁵³ Although the dates of the timbers are offered with caution, they will be included in this study because they are undoubtedly Portuguese and intended for ships.

⁵⁴⁸ As Castro (2003; 2006, 304; 2008, table 4) suggests.

⁵⁴⁹ Between 1635 and 1696 (Loureiro and Alves 2008, 274, n. 3).

⁵⁵⁰ Castro 2003, 38.

⁵⁵¹ See Chapter III.

⁵⁵² Alves 2002.

⁵⁵³ Alves 2002, 98.



Figure 20. Lisbon waterfront, ca. 1572. Shipbuilding area on beach (*Ribeira das Naus*?) and Ribeira Palace at right (from Braun and Hogenberg 1572, I-1).

Due to the exceptionally high standard of study and publication of the Pepper Wreck, a Portuguese Indiaman that sunk in 1606 in the Tagus River, its timbers are the most informative. Other Portuguese wrecks will be incorporated below where the study of their timbers yields relevant information. If vessels are not included in a discussion, it reflects a lack of published information, lack of archaeological material from which to interpret, or failure of the investigators to study the topic.

Tool Marks

Like many ships, evidence of tool marks on Portuguese vessels permits tentative reconstruction of a tool kit, albeit one probably incomplete. On the Pepper Wreck, adze,

auger, and saw marks were found.⁵⁵⁴ Again like those of many other shipwrecks, the timbers were in poor condition, damaged, and invaded by shipworm, underscoring the role that site formation processes play in the resulting interpretation of ship timber.⁵⁵⁵ Similarly, the Corpo Santo timbers revealed adze, or possibly a broad squaring axe, and saw marks,⁵⁵⁶ as do those from Ria de Aveiro A.⁵⁵⁷ The Praça do Município timbers demonstrate evidence of hand saws, but little else.⁵⁵⁸ Were only three types of tools used to build these vessels? This seems unlikely. In each case, the published discussion of tool marks is limited to, at most, a few paragraphs.

The Cais do Sodré wreck provides a sobering example in which post-excavation conditions must be considered in the "formation" processes. Due to political stagnation and other extenuating factors, once the timbers were excavated they were not conserved or further studied for approximately seven years.⁵⁵⁹ As Crumlin-Pedersen learned with the Skuldelev ships,⁵⁶⁰ once-obvious tool and carpenter's marks were almost lost and many less obvious marks certainly were. Excavation photographs had to be relied on to reconstruct degraded or destroyed information.

⁵⁵⁴ Castro 2005, 142-3.

⁵⁵⁵ See Castro's chapter on site formation for the Pepper Wreck (2005, 74-86).

⁵⁵⁶ Alves et al. 2001a, 418, figs 13-14.

⁵⁵⁷ Alves and Rieth 2005, 76-7.

⁵⁵⁸ Alves 2002, 97.

⁵⁵⁹ Castro 2002, 23.

⁵⁶⁰ See Chapter II; although the Skuldelev example was not neglect, but the result of early conservation efforts.

Assembly and Construction Marks

A hallmark of vessels built in the Iberian-tradition, construction marks on framing timbers, can be found on the Pepper Wreck, the Cais do Sodré wreck, and Ria de Aveiro A wreck (Fig. 21).⁵⁶¹ The timbers where these would be expected did not survive at Corpo Santo, and the Praça do Município timbers were not yet finished products, so in neither case should much evidence be anticipated. Construction marks are expected in the case of the Oranjemund wreck, but only further study will substantiate or refute this suspicion.

Several types of construction marks exist and have primarily been used to interpret construction sequences⁵⁶² and to identify other shipwrecks in the Iberiantradition. It is not only the marks that are useful but also their locations and orientation. Regular spacing between marks can be recorded and reveal the standard of measure used by the shipwright, timber supplier, or builder.⁵⁶³ In the case of the Pepper Wreck, spacing was based on the *rumo*, *goa*, and *palmo*,⁵⁶⁴ and this further confirmed the vessel's Portuguese design. For vessels with questionable origins, such information could be a considerable advantage for sourcing.

⁵⁶¹ Castro 2005, 118-28; Castro 2002, 11-2, table I, fig. 7; Alves et al 2001c, 20-5; Alves and Rieth 2005, 76-7.

⁵⁶² See especially Barker 1991.

⁵⁶³ This step is often overlooked, a trend which is not confined to any particular time or place of study.

⁵⁶⁴ Castro 2005, 122; Lavanha 1996, 151.



Figure 21. Construction marks from a Ria de Aveiro A floor timber (image inverted for ease of viewing; from Alves and Rieth 2005, 77).

When compared to Iberian shipbuilding treatises of the 16th and 17th centuries, timber markings can be better understood. For example, the presence of master frames (a significant philosophical advent in shipbuilding) is implied by an inverted numeral "V" on predesigned floor timbers from Ria de Aveiro A, Cais do Sodré, and the Pepper Wreck.⁵⁶⁵ The numerals *should* indicate a distance fore or aft of a known midships frame: the "master." Both Lavanha's and Oliveira's treatises indicate that ship timbers should have assembly, design, and construction markings, such as framing numbers, but

⁵⁶⁵ The master frames themselves have not survived; Castro 2005, 122.

the texts do not agree with one another on the finer points or completely with the available archaeological evidence.⁵⁶⁶

Castro's discussion of construction marks provides a five-part typology that, when slightly modified, accounts for all forms of evidence found on the collection of timbers in this study and contemporary texts (see Table 3): 1) sequential numbering of predesigned frames by Roman numerals, 2) vertical lines marking edges of the axis and keel, 3) lines marking the turn of the bilge, 4) marks from early timber processing or construction (including gauge marks), and 5) those for which no precise meaning can be discerned.⁵⁶⁷

The Pepper Wreck is the only vessel that has all of the listed markings, but it also dates much later than the other timbers, perhaps corresponding to a more structured or developed shipbuilding tradition. The Cais do Sodré wreck may have had all of the categories, but, as noted previously, this information is likely lost due to lack of proper conservation. It is tempting to draw comparative conclusions based on table 3, but this should be done carefully. Lack of evidence may be the result of site formation, preservation, conservation, or oversight by the investigators. At the very least, any timbers that fall primarily into categories 4 and 5 should be reinterpreted (before it is too late) and compared directly to Castro's observations, which are supported with photographs.

⁵⁶⁶ See Lavanha 1996, 52-55; Oliveira 1991, 94-97.

⁵⁶⁷ Castro 2005, 119-20; This fifth category may include the remnants of a "second level of surmarks" between the first and second *braços* in made frames, as indicated by Lavanha (1991, 148-51). It is likely these were obscured or cut away while working the timber.

Site/Ship	1	2	3	4	5
Pepper Wreck	Yes	Yes	Yes	Yes	Yes
Praça do Município	n/a	?	?	Yes	Yes
Oranjemund	?	?	?	?	?
Cais do Sodré	Yes	?	?	Yes	?
Ria de Aveiro A	Yes	?	?	Yes	Yes
Corpo Santo	No Data	No Data	No Data	Yes	?

Table 3. Correspondence with Castro's construction marks typology.

The interpretation of assembly and construction marks on Portuguese ships taken from the aggregation of data seems to indicate an organized tradition of shipbuilding, with "rules of thumb" or formal methods that became increasingly common over time. The construction and design of the later French ship *La Belle*, described in some detail in Chapter III, is reminiscent of the above methods. However, the Culip VI shipwreck, found in Catalonia and significantly predating the Portuguese vessels discussed here (early 14th century), also demonstrates some of the above methods. ⁵⁶⁸ The timbers of the Culip VI wreck, in turn, present evidence evocative of shipbuilding methods found in the Venetian *Fabrica di Galere* manuscript, some of which dates to ca. 1410.⁵⁶⁹ It is unlikely these similarities are a coincidence, but is this the result of diffusion or other cultural processes? When and where did the master-frame tradition begin? Did it get its start in the Mediterranean and travel westward? How? Was Portugal, as Barker suggests,

⁵⁶⁸ Palou and Rieth 1998.

⁵⁶⁹ Biblioteca Nazionale (Florence, Italy), Centrale di Firenze, codex Magliabecchiano, XIX.7; Jal 1840; McManamon 2001, 17-8.

"a meeting point for many traditions and a springboard for greater things?"⁵⁷⁰ Future investigations of construction marks on ships timbers may be able to contribute to a resolution of these broader questions.

Timber Size and Shape

Generally, structural timbers found in Portuguese ships are small, in comparison with those found in contemporary English or Dutch ships, for instance; in the case of the Pepper Wreck, they are very small. This is typically taken to be a sign of resource stress, as well as lack of forest management and general foresight.⁵⁷¹ The use of small timbers, however, should not necessarily be interpreted as such. Barker relays observations, or at least statements, from 17th and 18th century treatises that large ships made from large timbers "simply were not lasting as long as those made from small timber."⁵⁷² Did shipbuilders employ smaller timbers because, compared to the available larger timbers, they are structurally sounder, less expensive, easier to handle, or easier to stockpile? Such possibilities pose a dilemma of causality.

⁵⁷⁰ See especially Barker 2001, 213-28.

⁵⁷¹ For example, Castro 2005, 142; Alves et al. 2001c, 322.

⁵⁷² Barker also noted that when large timbers were used they required more waste to prepare them, perhaps up to 45 percent of the original circumference lost. Joining small timbers produced less waste (1998, 222).



Figure 22. Iberian-tradition dovetail joint without fasteners (after Oertling 1989b, fig. 5).

Indicators of quality should be considered in connection with timber size. Low quality cuts of timber, such as those with knots, cross-grain cuts, lack of heartwood, etc., are more likely to imply a lack of resources, despite size. For example, numerous patches on futtocks in the Pepper Wreck are likely indicative of limited quality.⁵⁷³ However, the use of dovetail joinery (Fig. 22) in the frames would seem contradictive of limited timber availability. Steffy states that the construction of dovetail joints:

"...required a lot of extra work and timber and, in light of the other fastenings, do not at first appear to have been necessary. But they did add some security to the joint and must have made frame assembly easier and more accurate. Their appearance on [many wrecks found outside the Mediterranean] indicates that, at least in the minds of their builders, their functional importance must have outweighed the additional labor and timber costs."574

⁵⁷³ Castro 2005, 115, 141, table 7.5. ⁵⁷⁴ Steffy 1994, 139.

The construction methods, then, cannot have been solely the result of timber shortages.

A composite keel is also often considered a result of timber procurement problems, and can be found in the Pepper Wreck⁵⁷⁵ and Ria de Aveiro A wreck.⁵⁷⁶ Lavanha's text contributes to (causes?) this interpretation by stating that single-piece keels are not strong enough, and his statement is traditionally cited to imply that this is due to lack of quality timber rather than choice.⁵⁷⁷ It is possible that the composite keels were indeed stronger, given the robust method of joinery employed in later vessels and as described by Lavanha (three bolts with a scarf: Fig. 23).⁵⁷⁸ Also, as vessels increased in size, additional structural considerations, such as a rocker to compensate for hogging,⁵⁷⁹ may have been required. It is unlikely that these standards could be met by individual trees with the frequency needed owing to the long occupation of the peninsula.580

The futtocks of the Pepper wreck further serve to illustrate that the quality of the cut is as informative as the size. Several futtocks in the Pepper Wreck had only small portions of heartwood remaining, and in some instances cork bark remained in section.⁵⁸¹ Heartwood provides strength and cork bark is a spongy: hardly an ideal combination for an India Route vessel. Apparently, "ideal" was not necessary, available, or both.

⁵⁷⁵ Castro 2005, 108-11, fig. 7.5. ⁵⁷⁶ Alves 2001b, 322.

⁵⁷⁷ Lavanha 1996, 44.

⁵⁷⁸ Lavanha 1996, 16, 44, 153-5, fig. 9).

⁵⁷⁹ Castro 2005, 111.

⁵⁸⁰ Figueiral 1996, 121-9; see also Da Silva (2001) for a discussion of Portuguese landscapes.

⁵⁸¹ Castro 2005 115



Figure 23. Scarfed and bolted keel sections (from Lavanha 1996, fig. 9, folio 62v).

Of the Ria de Aveiro A wreck, Alves et al. indicate that the floor timbers were roughly hewn and in most cases the original shape of the tree is obvious.⁵⁸² A single framing timber was found to have a twisted grain, and these two factors are taken together to reflect "a problem in the supply of high-quality wood due to environmental or economic constraints."⁵⁸³ This assumption does not follow, as demonstrated by Loewen's study of the Basque 24 M vessel.⁵⁸⁴ Additionally, Lavanha provides an alternate explanation:

- ⁵⁸² Alves 2001b, 325-6.
 ⁵⁸³ Alves 2001b, 326.
 ⁵⁸⁴ See Chapter III.

"Cut and felled, timbers may not immediately be applied to shipbuilding as they may not be able to stop twisting, shrinking and splitting... the timbers may be left many days either in the field, or in the shipyard or in salt water, according to their nature, and they may not be worked until after it is known of them that everything that may be feared has happened to them."⁵⁸⁵

Perhaps the single twisted timber was deadwood, worked while green, seasoned improperly, or was simply not "feared." The most likely reason is that the twisted timber was deadwood. Radial spiraling or distortion following the grain is a typical indication of deadwood. No apparent efforts have been made to pursue further study of these timbers using the method that Loewen developed, which can inform about the quality of the materials used in construction (i.e. relative timber ages, age clusters, timber conversion studies, wood anatomy). These timbers, being so close to their original size and shape would be ideal for such analyses.

Pressure on timber stores, whatever the cause, calls for ingenuity in ship construction. Shipbuilders devise technological solutions, such as new methods of joinery, and often these changes, once proven technologically or economically effective, become standard practice. Comparison of construction techniques over time may reveal the presence of resource stresses but will require further evidence to identify the stress(es).

⁵⁸⁵ Lavanha 1996, 145-6.

Species Identification and Use

Manuscripts from 16th and 17th century indicate that the preferred shipbuilding woods in Portugal were oak, especially cork oak (*Quercus suber*) for structural members (keels and frames) and stone or umbrella pine (*Pinus pinea*) for planking.⁵⁸⁶ Yet, as has been acknowledged by many scholars, only one Portuguese shipwreck typifies this pattern, the Pepper Wreck.⁵⁸⁷ The Pepper Wreck, from the end of the period under study here, is reminiscent of Mediterranean shipbuilding practices with its use of pine, and may indicate a shift in construction practices.⁵⁸⁸ Earlier Portuguese shipwrecks tend to employ oak throughout the hull, reminiscent of Northern European shipbuilding traditions (Table 4).

Quercus suber, *Q. faginea*, and *Q. robur* dominate Portuguese shipwrecks. The only major exception to this is the pine found in the hull planking of the Pepper Wreck. Some other species occur in minute proportions, such as *P. sylvestris* and *P. pinea* in the Cais do Sodré ceiling planking (port and starboard respectively) between the stringers and a *Crataegus monogyna* (hawthorn) whipstaff on the same ship.⁵⁸⁹ The Ria de Aveiro A wreck has *Castanea sativa* (chestnut) used for stanchions and *P. pinea* stowage billets.⁵⁹⁰ The Corpo Santo wreck's stern knee is *Q. rotundifolia* (Holm oak).⁵⁹¹ Such is the extent of variation in the timbers under consideration.⁵⁹²

⁵⁸⁶ Lavanha 1996,140-6 ; Oliveira 1991, 140-50.

⁵⁸⁷ Castro 2005, 141-2.

⁵⁸⁸ Barker 2001, 217-24; Alves et al. 2001a, 418.

⁵⁸⁹ Rodrigues n.d., 1-2.

⁵⁹⁰ Alves et al. 2001b, 341-2.

⁵⁹¹ Alves et al 2001a, 317-46.

⁵⁹² It is important to remember that little to no hull remains from above the turn of the bilge remain for any of the ships under study, and it is possible that other species would have been used in the upper works.

Site/Ship	Hull	Frames	Keel	Keelson	Stringers
		Q. suber			
Corpo Santo	Q. suber	Q. pyrenaica	?	?	?
Ria do					
Aveiro A	Q. robur	Q. robur	Q. robur	Q. robur	Q. robur
		Likely			
Oranjemund	?	<i>Quercus</i> sp.	?	?	?
Cais do	Q.				Q.
Sodré	faginea	Q. faginea	Q. faginea	Q. faginea	faginea
	Quercus				Quercus
Arade 1	spp.	Quercus spp.	Quercus spp.	Quercus spp.	spp.
Pepper					
Wreck	P. pinea	Q. suber	Q. suber	?	?

Table 4. Condensed timber species and uses (see Appendix).

Alves et al. suggest that the regular use of oak indicates an earlier tradition from a period prior to the "modern economy,"⁵⁹³ by which they could be referring only to the 16th century Portuguese expansion and accumulation wealth from the India trade. While oak planking may be a trademark of an earlier Portuguese shipbuilding tradition, I suggest that this is due not to economic concerns and intensive exploitation of oak stands in Portugal from the 15th to the 17th centuries but instead to the nature of the seafaring being conducted. The 15th century saw increasingly more ships headed southward into the tropics, and by the first quarter of the 16th century the India trade was firmly entrenched. Charles Boxer states that the average Indiaman made only four round trips in a lifetime,⁵⁹⁴ an average that is likely to have been considerably lower if the ships were planked in oak and traversing the warm waters so friendly to the shipworm, to which oak is particularly susceptible. Despite the inhibiting density of oaks, they lack

⁵⁹³ Alves et al. 2001a, 418; it is not entirely clear what form the authors think the pre-modern economy ⁵⁹⁴ Boxer 1969, 206-10.

inhibiting resins like pines, and are thus less ideal for planking.⁵⁹⁵ Until ventures were regularly headed south out of the Iberian Peninsula, there was likely little impetus to divert from the traditional ways of oak shipbuilding, which might have been introduced by the Northern Europeans who had frequented Portugal by sea since at least the 8th century.596

Summary

While investigations of ship timber have contributed a great deal to current information about Iberian-tradition ship construction methods, much information remains outstanding. Given the comparatively rich textual records, it is expected that these could be better evaluated by archaeological investigation even without discovery of additional ships. The archaeological remains from Portuguese vessels alone still retain a significant amount of cultural information. Discovery or salvage of additional hulls could, of course, further add to the corpus of knowledge, and more 16th century vessels are perhaps the priority.

Outside of the Basque region,⁵⁹⁷ which is exceptional in many respects, Iberian ships have not benefited from investigations of relative timber ages, age clusters, timber conversion studies, and wood anatomy. Each of these categories could, with little further investment, yield quality information about the people who built and designed these vessels, harvested and supplied the timber, and the culture in which they lived.

 ⁵⁹⁵ See Hoppe 2002, 116-9.
 ⁵⁹⁶ Kurlansky 2003, 129-43; 1999, 27-42.

⁵⁹⁷ See especially the discussion of the 24M vessel in Chapter II.

Currently, no dendrochronologies for the Iberian Peninsula exist in sufficient length or species to reach the 14th, 15th, 16th, or even 17th centuries. There is great potential and utility in incorporating and evaluating the above shipwrecks,⁵⁹⁸ especially the Pepper Wreck, Oranjemund ship, Ria de Aveiro A wreck, and Arade 1 ship. Steps should be taken immediately to collect the data from these timbers before it is lost or degraded.

As noted in Chapter III, some progress has been made in identifying genetic signatures of European oaks, including haplotypes of certain Portuguese stands. Given the apparently common use of oak, especially in early Portuguese ships, this is an avenue of research that should be investigated, but is likely to take many years to develop.

It is also worth noting that the treatises of Oliveira and Lavanha were transcribed, translated, and published prior to the discovery, excavation, and subsequent analysis of the ships in consideration. There is little doubt that this served to bias, albeit unintentionally, the researchers' expectations of results. For example, when only one excavated shipwreck exhibits the expected standard for species use and distribution,⁵⁹⁹ should this be considered the "standard"? Only subsequent excavations will be able to address this question, but it appears that sometime in the 16th century the use of oak for hull planking fell out of practice, likely as the result of a combination of causes.

⁵⁹⁸ As Castro (2005, 142) noted.

⁵⁹⁹ Pine hull planking and oak structural members, discussed above.

CHAPTER VII

CONCLUSIONS

The longstanding desire to understand ships as technological achievements that must be deconstructed, reconstructed, and slotted into their place in the history of watercraft evolution, as keys to the analysis of route or cargo, and as elements of other technological and economic inquires has overshadowed an understanding of ship timbers as individual artifacts and cultural indicators. Ship timbers must be investigated as methodically and thoroughly as any other artifact from the sites at which they are recovered.

To that end, the methodological approach outlined and evaluated in this dissertation is intended to serve as an aid to explore or perform analyses on any collection of ship timbers. As noted in the case studies presented above, cultural information is constantly at risk of loss or being overlooked on timbers, rendering it imperative that researchers be aware of the opportunities for analysis from the very outset of excavation.

Guide for the Cultural Investigation of Ship Timber

Below is a suggested guide to increase the cultural information that can be derived from a selection of ship timbers. It is critical to note that every collection of timbers will have circumstances specific to the site, preservation, deposition, logistics of excavation, study, and conservation. These circumstances may dictate that the suggested order below be changed, interrupted, or some steps ignored or are impossible. In general, after individual analysis timbers from a single vessel should be studied as a collection in search of patterns. Ultimately, timbers from contemporary vessels should be evaluated as a whole, building broader understandings of related cultural practices.

When ship timbers are excavated they should immediately be investigated for tool, assembly, and constructions marks. Assembly and construction marks are not typically prominent and are easily lost as handling and exposure of the timbers increases. Tool marks are generally more easily observed, but are at equal risk of loss. A photographic record of all faces of the timbers should be compiled as soon as possible, in case of incident. As evidenced by the investigation of the Skuldelev ships several factors can obscure or obliterate such markings, including conservation. When timbers have been in anaerobic environments and are then exposed to water, air, and light they can quickly change in shape, size, proportion, and color. Even when timbers are kept under the highest standard of care during study and conservation diagnostic information can be lost. Ideally, the timbers should be reinvestigated during and after conservation, as additional features may have gone overlooked or be exposed.

As demonstrated in all three case studies, the interpretation of tool marks can lead to the effective reconstruction of tool kits, though evidence of all tools employed may not remain. Again, evidenced in each case study the role of site formation, conservation, and the caliber of original craftsmanship are critical to the interpretation or recovery of tool marks.

Likewise, assembly and construction marks provide an opportunity to learn about the cultural processes behind shipbuilding. The use of construction or other marks on

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timber were valuable methods of communication between the designer, builder, and timber procurer or grower. Most of this workforce was likely illiterate, so simple marks could ensure that information was passed from one construction stage or worker to another, over time and distance.⁶⁰⁰ As the case studies demonstrate, it can be difficult to distinguish between the types of marks, but nonetheless, when properly recorded and studied such marks can provide a glimpse into the design and building processes.

Timber size and shape can be especially revealing of resource, economic, or environmental stresses, but must be combined with an evaluation of timber *quality* and technological ability. It is preferable to conduct these studies after confident reconstructions of the hull, or at least the remains, have been produced. Lines and construction drawings should provide perspective of the vessel as a whole. Evaluating these attributes proved to be effective in the Egyptian and Portuguese case studies. Unfortunately, not enough ship timber has been recovered from the Classical period to attempt comparative analyses between vessels.

When analyzing timber size, shape, and quality it is important to consider that choice plays an important role in ship construction and timber selection. Even if "ideal" timbers are obtained, the technology available to the builder may not permit their use in an ideal manner. Preferences and even tastes in ship construction can be unrelated to materials, availability, or ship technology and may affect the way a timber is prepared. When analyzing ship timbers, it is important to eliminate or account for such extenuating factors.

⁶⁰⁰ Atkinson 2007, 40.

Species identification and use may be the most common method of extracting cultural information from ships. Small samples, less than 1 cm x 1 cm x 1 cm, are typically required. If the wood has excellent or good preservation, only a few slivers can suffice. Dating and sourcing are the most common reasons for identifying wood types. However, the comparison of genera or species employed in a ship to the known species of suspected home port/origin for ships can also aid an understanding of the shipbuilding industry on local environments, reconstructing timber trade, quality of construction, and even construction philosophy As demonstrated specifically in the Greek case study, this method can be informative regardless of the volume of a ship that remains. Specimens for species identification, in addition to wood anatomy, and other dendrochronological applications should be taken after investigations for diagnostic surface information is completed.

Dendrochronological investigations (including relative timber ages, age clusters, timber conversion studies, reuse, and basic wood anatomy) are critical to extracting cultural information from ship timbers. The methods can be used to better understand build dates, repairs, lifetime of a vessel, timber sources, trade, economics, volume of wood required, resource stress, forestry practices (such as coppicing and pollarding), and timber-use patterns (such as seasoning and stockpiling). A systematic and thorough analysis of the methods involved in dendrochronological sampling of shipwrecked wood does not exist. That is, further work is needed to conclude whether waterlogged timbers should be sampled before conservation, after conservation, both, or go through a specific conservation process to maximize its utility. For example, Crumlin-Pederson et al. found difficulty in analyzing samples after conservation with PEG with the Skuldelev ships, while Kuniholm et al. found difficulty in dating samples from the Uluburun site prior to conservation.

Only the foundations for the study of cpDNA from ship timbers have been laid. While dry wood is preferred for analysis, it is possible to study waterlogged wood. The method is likely to prove informative regarding timber origins and distance traveled, but protocols for extraction of cpDNA from waterlogged wood are still being refined, terrestrial voucher collections are still being built, and it may be necessary to somehow rule out interference or contamination from underwater organisms through localized testing. Further studies from the timber of the *Mary Rose* are expected and will likely address such limitations in greater depth, potentially resolving them.

No applications of charcoal reflectance have been made to ship timbers, so methods must be vetted as well. This method has been used to reconstruct evidence of burn temperature, direction, source, and other cultural phenomena in archaeological wood and wood products, such as charcoal. The process itself is non-destructive, but preparation for analysis does require modification and extracting a small sample. It is likely preferable to desalinate the wood, if necessary, prior to testing and slowly air-dry the specimens. As some breakage while excavating charred wood from underwater sites seems inevitable, these small specimens can be utilized.

After investigation of the timbers themselves, significant opportunities to derive cultural information remain. Because wood use and consumption are relative to many factors, ship timber must be understood in context of its social, political, and economic

circumstances. Rackham provides a striking example: given that the *Olympias*, the experimental approximation of an ancient Greek trireme, weighed only 25 tons, "a whole fleet [of Greek triremes] could have been built for the volume of timber that went into [Lord Nelson's] *Victory*."⁶⁰¹ Contemporary accounts seem to imply that it was more difficult for the Athenians to build and maintain a single vessel, much less a fleet, than it was for the English to construct Nelson's flagship, but this cannot have been the case.

As demonstrated by the three case studies presented in this dissertation, it is important to include varied resources when interpreting ship timbers, and lack of primary material on which to rely, as in the Greek case study, is detrimental. It is possible that studies of the management of other resources, such as mines and quarries, may be able to serve as a proxy for understanding timber treatment or at least supplement the available information, especially in the Egyptian and Greek cases. Similarly, the availability of contemporary textual references, for example in the Greek and Portuguese studies, is a luxury that must, at times, be heavily relied upon. However, these sources, rather than be accepted at face value, should be evaluated in light of the archaeology because they often conflict with material evidence.⁶⁰²

The material evidence presents its own challenges. Archaeologists who study ships are generally forced to rely on a corpus of incomplete sites as the result of poor preservation, looting, and other detrimental factors.⁶⁰³ Timber remains likewise suffer. Nonetheless, the Portuguese case study exemplifies that, even under such constraints,

⁶⁰¹ Rackham 2001, 38.

⁶⁰² Rackham 2001, 8.

⁶⁰³ As Carlson has stated regarding the study of ships' cargo, especially amphorae (2004, 142).

wood can provide much cultural information. In the case of the Ma'agan Mikhael or Red Bay 24M wrecks, a single hull, if well preserved and well studied, can be exceptionally revealing of cultural practices associated with ship construction and design, but an individual vessel should not be interpreted as representative for an entire place or period. The greater the pool of evidence from which to draw, the higher quality the results are likely to be, although even poor hull remains can yield important information.

Summary

Other factors unrelated to the availability or quality of information and ship timbers have affected the results of this dissertation. Specifically, I originally intended to evaluate the social weight of a maritime power's forests. That is, investigate the implications of either having or lacking access to sufficient timber reserves for seafaring, the importance of the resource, and how it was viewed and addressed by a society. Such a task proved too large. Given the disparate locations and applications of timber investigations this task requires expertise in a large variety and volume of fields and periods, which I do not yet have.

While I still desired to address a "big-picture" question, it was necessary to pare the scope significantly for this work. During the paring process many questions that merit further investigation went under- or unaddressed, such as: how did populations obtain their ship timber? Did societies recognize a need to manage their timber resources, and, if so, did they take actions? Were dominant societies self-sufficient or dependent of foreign resources? Did the availability of adequate ship timber contribute to the growth, dominance, and decline of a society?⁶⁰⁴ While I am confident that these questions can be better understood through investigations of ship timber, I have not or have not been able to do so here.

The review, methods, and case-studies presented in this dissertation were pursued out of a perceived opportunity and need to better understand the people who built the ships and boats that have plied the world's oceans, seas, rivers, and lakes for thousands of years. Far more can be learned about them from thorough studies of ship timber than has generally been achieved in the past. Of all specialists working with shipwrecks, the archaeologist(s) who excavates and reconstructs a vessel is in the best position to develop a comprehensive understanding of the material, and, in general, could take greater advantage of this opportunity.

Regardless of the limitations of this work, I hope it has still demonstrated that more thorough analyses of ship timbers can lead to a better understanding of many aspects of culture. Such information extends far beyond the scope of a ship's final voyage or trade route and into the forests from which the ships' timbers were harvested.

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⁶⁰⁴ A prominent example of societal collapse in which lack of timber resources played a significant role is that of Rapa Nui, also known as Easter Island (see Diamond 2005, 79-119).

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APPENDIX

This appendix is intended to provide a summary perspective on the primary ship timbers noted in the case studies, and related evidence. A summary of the wood remains and pertinent notes includes the essential reference(s) for the remaining timber. Species/use tables are also provided in greater detail here (Tables 5, 6, 7) than in the case studies.¹

Ancient Egypt

Tarkhan planks

Tarkhan cemetery, Lower Egypt; Early Dynastic, ca. 3100 B.C.E.

Remains: Two or three planks and fragments from coffins and lids, suggested to have, at some time, been employed in boats. Currently, no way to prove this assumption, or what part of a boat they may have constituted, but largely accepted as a plausible hypothesis. Scientific species identification has not been made to date.

References: Petrie, W., G. Wainwright, and A. Gardiner. 1913. Tarkhan I and Memphis

V. London: Bernard Quaritch; Vinson, S. 1994. Egyptian Boats and Ships.

Buckinghamshire: Shire Egyptology, 17-20; Ward, C. 2000. Sacred and Secular.

Philadelphia: University of Pennsylvania Museum, 32-6.

¹ This small database was inspired by J. Richard Steffy's "ShipData Project." John Littlefield played a significant role in gathering data and citations for this Appendix, while working on an internship under my direction with the Laboratory of Tree-Ring Research at the University of Arizona. I am indebted to Mr. Steffy and grateful for the assistance of John and the Tree-Ring Lab with the Appendix. Citations or any other use of this Appendix should reference the people and organizations in this footnote.

Abydos boats

Abydos, Egypt; 1st Dynasty, ca. 3050 B.C.E.

Remains: Fourteen boats, between 19 and 29 m in length, interred in mud-brick superstructures immediately northeast of king Khasekhemwy's enclosure, each assumed to contain, or to have contained a long, shallow wooden riverine vessel. Only three meters of a single boat, Grave 10, has been excavated. Wood is in very poor state of preservation. No framing or other known structures other than hull planking. Lashed construction, no known mortise-and-tenons. Further excavation is planned for an undetermined time.

References: Ward, C. 2000. *Sacred and Secular*. Philadelphia: University of Pennsylvania Museum, 39-43; Ward, C. 2006. "Boat-Building and its Social Context in Early Egypt: Interpretations from the First Dynasty Boat-Grave Cemetery at Abydos." *Antiquity* 80:118-29; O'Connor, D. 2009. *Abydos: Egypt's First Pharaohs and the Cult of Osiris*. London: Thames & Hudson, 183-94.

Khufu vessels (also known as: Khufu I, Khufu II, and Cheops "barge/boat/ship(s)") Giza, Egypt; 4th Dynasty, ca. 2550 B.C.E.

Remains: Two vessels, between 40 and 45 m in length, buried adjacent to Khufu's pyramid. Approximately 40 tons of wood per vessel. One vessel exhumed, reconstructed and on display, second vessel remains in pit, but is deteriorating rapidly and plans by the Japanese mission in Egypt (Waseda University?) to excavate and conserve have been rumored for at least five years. Preservation of Khufu I, on display, is excellent. Hull

planks, internal framing members, deck planks, superstructures, oars, and other ornamental items remain, most are cedar. Timbers are joggled, laced, and have light use of edge joinery by mortise-and-tenon.

References: Nour, M.Z., Z.Y. Iskandar, M.S Osman, and A.Y. Moustafa. 1960. *The Cheops Boat,* Part I. Cairo: Egyptian Government Press; Lipke, P. 1984. *The Royal Ship of Cheops. BAR International Series* 225. Oxford: Archaeopress; Ward, C. 2000. *Sacred and Secular.* Philadelphia: University of Pennsylvania Museum, 45-68; Marks, S. 2009. "The Construction of the Khufu I vessel (c.2566 BC): a Re-Evaluation." *International Journal of Nautical Archaeology* 38:133-52.

Ayn Soukhna boats (alternate spellings: Ayn Sokhna, Ain Soukhna)

Ayn Soukhna, Egypt; Old and Middle Kingdoms, ca. 2000 B.C.E.

Remains: At least two burned vessels found carefully disarticulated in caves near the Red Sea. Under analysis by Patrice Pomey. Expect further published information in the proceedings from *ISBSA* 12, Istanbul 2009.

References: Abd el-Raziq, M. 2008, 2 April. '*Ayn-Soukhna*. http://www.ifao.egnet.net/ archeologie/ ayn-soukhna/ (12 April 2010); Pomey, P. 2009. "Ancient Ship Remains Unearthed at Ayn Soukhna on the Gulf of Suez." *Pharos: Newsletter of the Alexandria Centre for Maritime Archaeology & Underwater Cultural Heritage* 1:2.

Wadi Gawasis remains (also known as: Mersa Gasus, Mersa Gawasis) South of Safaga, Egypt; Old and Middle Kingdoms, ca. 1950 B.C.E. Remains: Various ship parts, including ropes, planks, oars, stanchions, hull planks, deck planks, and gribble. No single vessel or articulated portion thereof remains. The site was a port or way station, potentially the ancient site of *Saww*, and evidence suggests careening or ship assembly/disassembly occurred at this location. Remains are the debris from these activities and possible stores for later voyages that never occurred. References: Annual reports posted on www.archaeogate.org; Bard, K., and R. Fattovich, eds. 2007. *Harbor of the Pharaohs to the Land of Punt: Archaeological Investigations at Mersa/Wadi Gawasis Egypt, 2000–2005*. Napoli: Università degli Studi di Napoli L'Orientale; Ward, C.A., and C. Zazzaro. 2010. "Evidence for Pharaonic Seagoing Ships at Mersa/Wadi Gawasis, Egypt." *International Journal of Nautical Archaeology* 39(1) 26–43; Ward, C., C. Zazzaro, and M. Abd El-Maguid. Forthcoming. "Super-Sized Egyptian Ships." *International Journal of Nautical Archaeology*.

Lisht work boat timbers

Senwosret I complex, Lisht, Egypt; 12th Dynasty, ca. 1950 B.C.E.

Remains: Disarticulated Nilotic work boat timbers, used as supports for construction ramps at at least six locations on site. One internal framing member was reconstructed, as well as potentially a section of hull. Finds could represent multiple vessels. Most timbers were poorly preserved, some only stains in the soil. Better preserved timbers were reburied. Mortise-and-tenon joinery with internal lashing.

References: Haldane, C.W. 1988. "Boat Timbers from El-Lisht: a New Method of Ancient Egyptian Hull Construction: Preliminary Report." *Mariner's Mirror* 74: 141– 52; Haldane, C.W. 1992. 'The Lisht Timbers: a Report on Their Significance." In *The Pyramid Complex of Senwosret I: the Southern Cemeteries of Lisht*, edited by D. Arnold, 102-12. New York: The Metropolitan Museum of Art; Ward, C. 2000. *Sacred and Secular*. Philadelphia: University of Pennsylvania Museum, 107-28.

Lahun timbers

Senwosret I and Amenemhat III complexes, Lisht, Egypt; 12th Dynasty, ca. 1950 B.C.E. Remains: Disarticulated boat timbers, used as supports for construction ramps. Most timbers were apparently well preserved, but "consumed" in the course of other activities at the site. Excavators only noted their existence without preservation or study, some photographs exist. Finds included a quarter rudder.

Reference: Petrie, F., G. Brunton, and M.A. Murray. 1923. *Lahun*. Vol. 2. British School of Archaeology in Egypt/Egyptian Research Account 33. London: Bernard Quaritch.

Dahshur boats (also known as: Pittsburgh/Carnegie boat; Chicago/Field Museum boat; Cairo boats, Red boat, White boat)

Senwosret III complex, Lisht, Egypt; 12th Dynasty, ca. 1850 B.C.E.

Remains: At least four, probably five, near-complete Nilotic boats, between 9 and 10 m in length, presumed funerary. Current locations: two in Cairo Museum, one in Pittsburgh's Carnegie Museum, one in Chicago's Field Museum. One vessel unaccounted for, presumed lost. Very good preservation includes hull planks, deck

planks, stanchions, quarter rudders, and throughbeams. Deep mortise-and-tenon joinery, possibly with interior fastenings.

References: De Morgan, J.J. 1895. Fouilles à Dâhchour: Mars–Juin 1894. Vienna:
Adolph Holzhausen; Patch, D.C., and C. Haldane. 1990. The Pharaoh's Boat at The Carnegie. Pittsburgh: The Carnegie Museum; Ward, C. 2000. Sacred and Secular.
Philadelphia: University of Pennsylvania, 83-102; Creasman, P.P. 2005. "The Cairo Dahshur Boats." M.A. thesis, Texas A&M University; Creasman, P.P., D. Sassen, S.
Koepnick, and N. Doyle. 2010. "Ground-Penetrating Radar Survey at the Pyramid Complex of Senwosret III at Dahshur, Egypt, 2008: Search for the Lost Boat of a Pharaoh." Journal of Archaeological Science 37(3):516-24; Creasman, P.P.
Forthcoming. "A Further Investigation of the Cairo Dahshur Boats." Journal of Egyptian Archaeology.

Bronze Age

Uluburun shipwreck

Wrecked off Uluburun peninsula, near Kaş, Turkey; Late Bronze Age, ca. 1315 B.C.E. Remains: Merchant vessel between 15 and 16 m in length. Limited hull remains with extremely poor preservation, but built in shell-first tradition with pegged mortise-andtenons. Keel-plank, garboard, and portions of several strakes remain. No evidence of frames.

References: Pulak, C. 1998. "The Uluburun Shipwreck: an Overview." *International Journal of Nautical Archaeology* 27(3):188-224; Pulak, C. 2002. "The Uluburun Hull

Remains." In *Tropis* VII, *Seventh International Symposium on Ship Construction in Antiquity Proceedings*, edited by H. Tzalas, 615-36. Athens: Hellenic Institute for the Preservation of Nautical Tradition.

Cape Gelidonya shipwreck

Wrecked off Cape Gelidonya, southwest Turkey; Late Bronze Age, late 13th cy. B.C.E. Remains: Approximately 50 small fragments, the largest measuring less than 24 x 14 x 6 cm. Most were distorted after excavation due to rapid air drying. Species identification difficult due to wood impregnation by copper salts and metallic copper.

Reference: Bass, G.F. ed. 1967. *Cape Gelidonya: A Bronze Age Shipwreck. Transactions* of the American Philosophical Society 57.8. Philadelphia: American Philosophical Society.

Archaic period

Pointe Lequin 1A shipwreck

Porquerolles Island, near Toulon, France; late 6th century B.C.E.

Remains: Little timber, fragmentary, includes the rudder. Length ca. 20 m.

References: Long, L., J. Miro, and G. Volpe. 1992. "Les Épaves archaïques de la Pointe Lequin (Porquerolles, Hyères, Var)." In *Marseille grecque et la Gaule*, Etudes Massaliètes 3, edited by M. Bats, G. Bertucchi, G. Conges, and H. Treziny, 199-234; Long, L., and J.-C. Sourrisseau. 2002d. "Épave Pointe Lequin 1A." In *Les Étrusques en mer: Épaves d'Antibes à Marseille*, edited by L. Long, P. Pomey, J.-C. Sourisseau, 50-4. Marseille: Musées de

Marseille; Krotscheck, U. 2008. "Scale, Structure, and Organization of Archaic Maritime Trade in the Western Mediterranean: the 'Pointe Lequin 1A.'" Ph.D. diss., Stanford University.

Pabuç Burnu shipwreck

Southwest Turkey; 2nd quarter of the 6th century B.C.E.

Remains: Little wood remains, including: 7 substantial fragments from the hull, comprising less than 2 percent of the vessel. Length ca. 20 m, sewn construction. Reference: Polzer, M. 2004. "An Archaic Laced Hull in the Aegean: the 2003 Excavation and Study of the Pabuç Burnu Ship Remains." *INA Quarterly* 31(3):3-11.

Bon Porté shipwreck

Ramatuelle, near Saint-Tropez, France; ca. 525 B.C.E.

Remains: Limited timber, including portions of: keel, 5 strakes, 5 full frames, mast step. Length assumed between 7 and 10 m, sewn construction.

References: Joncheray, J. P. 1976. "L'epave grecque, ou etrusque, de Bon Porte." *Les cahiers darchbologie Suhaquatique* 5:5-36; Pomey, P. 1981. "L'Épave de Bon-Porté et les bateaux cousus de Mediterranée." *Mariner's Mirror* 7:225-43.

Grand Ribaud F shipwreck

Hyères Islands, France; ca. 525-485 B.C.E.

Remains: Extent unknown, but apparently good preservation, including: hull planking, keel, stern post, keelson, stanchions, floors. Wreck found at 50 m and investigated primarily by ROV.

Reference: Long, L., P. Drap, L.-F. Gantes, and M. Rival. 2001. *L'épave Grand Ribaud F: Rapport scientifique intermédiaire année 2001*. http://grandribaudf.gamsau.archi.fr/ grf2001.html (1 March 2008); Long, L. and P. Drap. 2001. "Towards a Digital Excavation Data Management System: The "Grand Ribaud F" Estruscan [sic] Deep-Water Wreck." In *Virtual Reality, Archeology, and Cultural Heritage: Proceedings of the 2001 Conference on Virtual Reality, Archeology, and Cultural Heritage*, 17-26. New York: ACM.

Jules-Verne 7 shipwreck

Marseilles, France; ca. 525 B.C.E.

Remains: Extensive wood remains, including: keel, stem and stern posts, garboards, portions of 22 strakes, 4 wales, full frames, treenails, tenons. Estimated 16 m in length, shell-first, sewn construction.

Reference: Pomey, P. 1995. "Les Épaves Greques et Romaines de la Place Jules-Verne à Marseille." *Comptes Rendus des Séances de l'Année 1995* 139(2):459-84.

Jules-Verne 9 shipwreck

Marseilles, France; ca. 515 B.C.E.

Remains: Some wood remains, including portions of: keel, 8 strakes, one frame.

Estimated 9.5 m in length, shell-first, sewn construction.

Reference: Pomey, P. 1995. "Les Épaves Greques et Romaines de la Place Jules-Verne à Marseille." *Comptes Rendus des Séances de l'Année 1995* 139(2):459-84.

Gela 1 shipwreck

Gela, southern Sicily, Italy; ca. 500 B.C.E.

Remains: Extensive hull remains, including: keel, 17 strakes, endposts, planks, 17 full frames, mast step, dowels. Estimated 17 m in length, shell-first, sewn construction. References: Panvini, R. 2001. *The Archaic Greek Ship at Gela: And Preliminary Exploration of a Second Greek Shipwreck*. Palermo: Regione Siciliana.

Classical period

Gela 2 shipwreck

Gela, southern Sicily, Italy; ca. 475 B.C.E.

Remains: Extensive hull remains, but the timber was compressed by ballast, currently in conservation and includes: keel, hull planks, full frames. Estimated 17 m in length, wineglass cross-section, shell-first, mortise-and-tenons.

References: Benini, A. 2001. "Il second relitto de Gela: note di architettura navale." In *La nave greca arcaica di Gela*, edited by R. Panvini, 97-106, 152-3. Palermo: Salvatore Sciascia.

Phagrou shipwreck

Islet near Kyra Panagia, Northern Sporades, Greece; ca. 450 B.C.E.

Remains: Unknown. Excavation limited to one 2 x 2 m unit.

References: Touchais, G. 1996. "Chronique des fouilles et decou-vertes archeologiques en Grece en 1995." *Bulletin de correspondance hellénique* 120:1109-373; Kazianes, D. 1996. "Phagrou Voreion Sporadon." *Archaiologikon Deltion* 51:724-5

Tektaş Burnu shipwreck

Western Turkey; ca. 440-425 B.C.E.

Remains: No substantial timber remains, only bits of largely undermined location.

Length ca. 11 m, probably pegged mortise-and-tenon construction.

References: Carlson, D.N. 2003. "The Classical Greek Shipwreck at Tektaş Burnu,

Turkey." American Journal of Archaeology 107(4):594-6; Jurgens, J.A., R. Blanchette,

and D.N. Carlson. 2003. "Evaluating the Wooden Remnants of the Tektas Burnu

Shipwreck." In Art, Biology, and Conservation: Biodeterioration of Works of Art, edited

by R.J. Koestler, V.H. Koestler, A.E. Charola, and F.E. Nieto-Fernandez, 390-407. New

York: The Metropolitan Museum of Art.

Alonnesos shipwreck

Northern Sporades, Greece; ca. 420-400 B.C.E.
Remains: Likely. Two 2x 2 m grids were excavated and in one charcoal and chunks of unburned wood were found. Large merchant vessel.

References: Hadjidaki, E. 1996. "Underwater Excavations of a Late Fifth Century Merchant Ship at Alonnesos, Greece: The 1991-1993 Seasons." *Bulletin de correspondance hellénique* 120:561-93.

Porticello shipwreck (also known as the Straits of Messina shipwreck) Straits of Messina, between Sicily and mainland Italy; ca. 415-385 B.C.E. Remains: Scattered small fragments, poor preservation. Wreck was looted prior to archaeological investigation. Length ca. 16 m, probably pegged mortise-and-tenon construction.

Reference: Eisman, C.J., and B.S. Ridgway. 1987. *The Porticello Shipwreck: A Mediterranean Merchant Vessel of 415-385 B.C.* College Station: Texas A&M University Press, 10-6, 24 table 1.

Ma'agan Mikhael shipwreck

Kibbutz of Ma'agan Mikhael, Israel; ca. 400 B.C.E.

Remains: Extensive hull remains, excellent preservation, includes: keel, false keel, mast step, 17 strakes, knees, at least 14 frames, stringer (keelson), stanchions, at least two wales, mast partner, endposts. Estimated 14 m in length, wineglass cross-section, shellfirst, pegged mortise-and-tenons, sewn extremities. Reference: Kahanov, Y., E. Linder, and J. Tresman. *The Ma'agan Mikhael Ship*. Vol. 2. Jerusalem: Old City Press.

Mataria boat

Northeastern Cairo, Egypt; ca. 400 B.C.E

Remains: Extensive hull planking remains. Length is greater than 8 m. Mortise-andtenons, some pegged.

Reference: Ward, C. 2000. Sacred and Secular. Philadelphia: University of

Pennsylvania Museum, 129-35.

El Sec shipwreck

Majorca, Spain; ca. 340 B.C.E

Remains: Good, but many factors complicate site and interpretation, including: looting, navy's use of munitions to free concretions, and only partial excavation. Hull planks and frames suggest robust built. Length possibly 25 to 30 m, probably Punic.

References: Arribas, A., G. Trias, D. Cerda, and J. de la Hoz. 1987. *El barco de El Sec (Calvià, Mallorca): Estudio de los materiales*. Mallorca: Exm. Ajuntamento de Calvià.

Kyrenia shipwreck

Remains: Approximately 75 percent of the hull, including: keel, 23 strakes, 3 wales, ceiling planking, 56 frames, stem, knee. Length ca. 14 m.

References: Steffy, J.R. 1989. "The Kyrenia Ship: An Interim Report on Its Hull Construction." *American Journal of Archaeology* 89(1):71-101; Steffy, J.R. 1994. *Wooden Ship Building and the Interpretation of Shipwrecks*. College Station: Texas A&M University Press, 42-59.

The Portuguese during the Age of Discovery

Corpo Santo shipwreck

Lisbon, Portugal; ca. 1390 C.E.

Remains: Good preservation of minimal remains, including portions of ten pieces from the stern of a vessel: 3 frames, 5 strakes, heel, stern knee. Length ca. 13 m. Reference: Alves, F., E. Rieth, and P. Rodrigues. 2001. "The Remains of a 14th-century Shipwreck at Corpo Santo and of a Shipyard at Praça do Municípo, Lisbon, Portugal." In *Proceedings of the International Symposium on Archaeology of Medieval and Modern Ships of Iberian-Atlantic Tradition*, edited by F. Alves, 405-26. Lisbon: Instituto Português de Arqueologia.

Ria de Aveiro A shipwreck

Aveiro Lagoon, Mira Channel, Portugal; ca. 1440 C.E.

Remains: Very good preservation of approximately the bottom 1 m of the hull, from midships to stern, including portions of: keel, 23 frames, 12 strakes, heel. Length ca. 12.5 m.

References: Alves, F., E. Rieth, P. Rodrigues, M. Aleluia, R. Rodrigo, C. Garcia, and E.
Riccardi. 2001. "The Hull Remains of Ria de Aveiro A, a Mid-15th Century Shipwreck
from Portugal: A Preliminary Analysis." In *Proceedings of the International Symposium on Archaeology of Medieval and Modern Ships of Iberian-Atlantic Tradition*, edited by
F. Alves, 317-46. Lisbon: Instituto Português de Arqueologia; Alves, F., P. Rodrigues,
M. Aleluia, R. Rodrigo, and C. Garcia. 2001. "Ria de Aveiro A: a Shipwreck from
Portugal Dating to the Mid-15th Century; a Preliminary Report." *International Journal of Nautical Archaeology* 30(1):12-36; Alves F., and E. Rieth. 2005. Um Mergulho na *História O navio do século XV Ria de Aveiro A*. Ílhavo: Centro Nacional de Arqueologia
Náutica e Subaquática.

Cais do Sodré shipwreck

Lisbon, Portugal; ca. 1475 C.E.

Remains: Very good preservation of approximately the lowest half-meter of the hull, including portions of: keel, 15 strakes, approximately 50 frames, ceiling planks. Length, ca. 28 m.

References: Rodrigues, P., F. Alves, E. Rieth, and F. Castro. 2001. "L'épave d'un navire de la deuxième moitié du XVème siècle / début du XVIème, trouvee au Cais do Sodré (Lisbonne)." In *Proceedings of the International Symposium on Archaeology of Medieval and Modern Ships of Iberian-Atlantic Tradition*, edited by F. Alves, 347-79. Lisbon: Instituto Português de Arqueologia; Castro. F. 2002. *The Cais do Sodré Ship Frames—2002 Field Season*. ShipLab Report 4. College Station: Texas A&M University; Rodrigues. P. n.d. "The Cais do Sodré Ship." Report on file in the Nautical Archaeology Program Library. College Station: Texas A&M University.

Praça do Município timbers

Lisbon, Portugal; early 16th century C.E.

Remains: Disarticulated, unfinished timbers, presumably for ships. Eleven significant timbers, some fragmented, probably a keel timber and 10 floors.

Reference: Alves, F., E. Rieth, and P. Rodrigues. 2001. "The Remains of a 14th-century Shipwreck at Corpo Santo and of a Shipyard at Praça do Municípo, Lisbon, Portugal." In *Proceedings of the International Symposium on Archaeology of Medieval and Modern Ships of Iberian-Atlantic Tradition*, edited by F. Alves, 420-23. Lisbon: Instituto Português de Arqueologia; Alves, J.G. 2002. "Approche archéologique d'un chantier naval médiéval. La découverte des vestiges d'architecture navale de la Praça do Município, Lisbonne, Portugal." M.A. thesis, Université de Paris I – Sorbonne.

Oranjemund shipwreck (also known as the Namibia/Diamond wreck, *Bom Jesus*) Namibia; ca. 1530 C.E.

Remains: Currently unpublished, but only a "scant" portion of the hull has been recovered, including portions of: 4 futtocks, shelf clamp, ceiling planking, hull planking. Apparently good preservation of what has been found.

References: Castro, F., and L. Thomas. Forthcoming. "The Oranjemund Shipwreck and the Portuguese India Route Ships."; Alves, F. 2009. *O navio português do século XVI de*

Oranjemund, Namíbia. Relatório das missões realizadas pela equipa portuguesa em 2008 e 2009. Trabalhos da DANS, 45. Lisbon: IGESPAR.

The Pepper Wreck (also known as Nossa Senhora do Martíres)

Mouth of the Tagus River, Portugal; ca. 1606 C.E.

Remains: Good preservation of a small portion of the bottom of the ship, forward of midships, including portions of: keel, 11 frames, 26 strakes, apron. Length ca. 28 m. Reference: Castro, F. 2005. *The Pepper Wreck: A Portuguese Indiaman at the Mouth of the Tagus River*. College Station: Texas A&M University Press.

Arade 1 shipwreck

Mouth of the Arade River, Portugal; 15th or 16th century C.E.

Remains: Good preservation, including portions of: keel, stempost, apron, keelson, 18 frames, 4 ceiling strakes, 2 hull strakes on port side, and 8 on starboard side. The hull was broken near midships, and only half was preserved. Length ca. 13 m. References: Castro, F. 2003. *The Arade 1 Ship—2002 Field Season*. Vol. 2, *The Hull*. ShipLab Report 5. College Station: Texas A&M University; Castro, F. 2006. "The Arade 1 Shipwreck. A Small Ship at the Mouth of the Arade River, Portugal." In *Connected by the Sea*, edited by L. Blue, F. Hocker, and A. Englert, 300-5. *International Symposium on Boat and Ship Archaeology* 10. Oxford: Oxbow Books.

Other/ Unidentified Use						Faidberhia alhida	Avicennia, Pinus sp.,	Quercus sp.								Quercus sp., Tamarix sp., Fraxinus sp.	Pinus sylvestris , Albes alba , Quercus sp., Ulmus sp., Phillyrea sp., Buxus sempervirens
Pegs			Acacia sp. and Ficus sycomorus							n/a		n/a	n/a	n/a	n/a	Quercus coccifera	د.
Tenons	i	ć	Ziziphus spina- christi	ė	Acacia sp.		Acacia	nilotica	Tamarix sp.,	Acacia sp.	ż	Tamarix sp.	likely Tamarix sp.	likely Tamarix sp.	likely Tamarix sp.	Quercus sp.	Quercus sp.
Deck	i	ė	Cedrus libani	ė	ė	Cedrus libani, Ficus	sycomorus,	Acacia vilotica		ż	ż	Cedrus libani	Cedrus libani	likely Cedrus libani	likely Cedrus libani	ć	د.
Hull	Ficus sycomorus	Likely Tamarix sp.	Cedrus libani	ć	Cedrus sp., Quercus sp.			Cedrus libani	Acacia sp.,	Tamarix sp.	ć	Cedrus libani	Cedrus libani	Cedrus libani	Cedrus libani	Cedrus sp.	Cedrus libani , Pinus brutia , Quercus sp.
Frames	n/a	n/a	Cedrus libani	i	n/a			Cedrus libani		i	ć	n/a	n/a	n/a	n/a	i	ć
Keel	n/a	n/a	n/a		n/a			n/a				n/a	n/a	n/a	n/a	Cedrus sp.	ć
Name	Tarkhan planks	Abydos	Khufu I	Khufu II	Ayn Soukhna			Mersa/ Wadi Gawasis		Lisht	Lahun	Chicago Dahshur	Pittsburgh Dahshur	Cairo Red Dahshur	Cairo White Dahshur	Uluburun	Cape Gelidonya

Table 5. Ancient Egyptian and Bronze Age Mediterranean ship timber

Name	Keel	Hull planking	Frames	Keelson	Tenons	Treenails	Pegs	Other/ Unidentified Use
Pabuc Burnu	i	Pinus nigra	ż	i	i	i	ć	
Bon Porte	i	Pinus sp.	Pinus sp.	6	2	ć	i	
Jules-Verne 7	Quercus sp.	Pinus sp.	Pinus sp., black alder	6	Olea sp.	ė	i	
Jules-Verne 9	Quercus sp.	Pinus sp.	Pinus sp.	6	i	Olea sp.	i	
Gela 1	Pinus pinea	ż	Pinus pinea	Pinus pinea	i	ć	i	Salix sp.
Gela 2	i	Pinus sp.	Quercus sp.	6	Quercus sp.	ċ	i	Strut: Acer sp.
Tektaş Burnu	ė	Pinus sp. and/or Quercus sp.	Quercus sp. and/or Pinus sp.	i	Likely Quercus sp.	ż	i	Ulmus sp.
Porticello	i	Pinus sp.	ė	i	i	ż	ć	
Ma'agan Michael	Pinus brutia	Pinus brutia	Pinus brutia	Quercus sp.	Quercus coccifera , Fagus sp.	Pinus brutia	Quercus coccifera , Quercus petrea , Fraxinus excelsior	Stem, false sternpost, bow knee, stern knee, wales, mast step, stringers, mast board, stanchions: <i>Pinus</i> <i>brutia</i>
Mataria	ć	Ficus sycomorus, at least three other types	n/a	n/a	Zizyphus sp.	n/a	i	
Kyrenia	Likely Pinus halepensis	Likely Pinus halepensis	Likely Pinus halepensis	n/a	Quercus cerris	Likely Pinus halepensis	Quercus sp.	False keet. Pinus halepensis Mast step: Pinus halepensis
Athlit Ram	Red pine group	Red pine group	i	i	Quercus sp.	ć	Quercus sp.	Stem/ramming timber: Ceatrus sp. Chock/nosing timber: Ulmus sp.

Table 6. Archaic and Classical period ship timber.

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Name	Keel	Keelson	Frames	Hull	Stern Knee	Other/ Unidentified Use
Corpo Santo	Quercus suber		Quercus suber, Q. pyrenaica	Quercus suber	Quercus rotundifolia	Sternpost. Quercus suber
Ria de Aveiro A	Quercus robur	Quercus robur	Quercus robur	Quercus robur	Quercus robur	Heel: Quercus robur, Stempost: Quercus sp., Stringers: Quercus sp.
Cais do Sodré	Quercus faginea	Quercus faginea	Quercus faginea	Quercus faginea		Apron: Quercus faginea, Breast hook: Q. robur, Ceiling: Pinus pinea and P. sylvestris, Stringers: Q. faginea, Whipstaff: Crataegus monogyna
Praça do Município	Likely Quercus faginea		Quercus faginea			
Oranjemund			Likely Quercus sp.	6		Ceiling: likely <i>Pinus</i> sp., Clamp: ?
The Pepper Wreck	Quercus suber		Quercus suber	Pinus pinea		Apron: Quercus sp.
Arade 1	Quercus sp.	Quercus sp.	Quercus sp.	Quercus sp.	Quercus sp.	Apron: Quercus sp., Ceiling: Quercus sp.

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Recent Publications:	 Web Page: http://www.imrd.org (since June 2005). Creasman, P.P. Forthcoming. "A Further Investigation of the Cairo Dahshur Boats." <i>The Journal of Egyptian Archaeology.</i> Creasman, P.P., and N. Doyle. 2010. "Overland Boat Transportation in Ancient Egypt: Archaeology & Iconography." <i>Journal of Ancient Egyptian Interconnections</i> 2(3):14-30. Creasman, P.P., Sassen, D., Koepnick, S., and N. Doyle. 2010. "Ground-Penetrating Radar Survey at the Pyramid Complex of Senwosret III at Dahshur, Egypt, 2008: Search for the Lost Boat of a Pharaoh." <i>Journal of Archaeological Science</i> 37(3):516-524. Towner, R. H., and P.P. Creasman. 2010. "Historical Dendroarchaeology in the El Malpais: Lessons from the Savage Homestead." <i>Historical Archaeology</i> 44(4): in press. Creasman, P.P., Vining, B., Koepnick, S., and N. Doyle. 2009. "An Exploratory Geophysical Survey at the Pyramid Complex of Senwosret III at Dahshur, in Search of Boats." <i>The International Journal of Nautical Archaeology</i> 38(2):386-399.