

Timber Supply for Byzantine Shipbuilding

by

Zeynep Olgun

A Dissertation Submitted to the

Graduate School of Social Sciences and Humanities

in Partial Fulfilment of the Requirements for

the Degree of

Master of Arts

in

Archaeology and History of Art



**KOÇ
ÜNİVERSİTESİ**

August 2020

Timber Supply for Byzantine Shipbuilding

Koç University

Graduate School of Social Sciences and Humanities

This is to certify that I have examined this copy of a master's thesis by

Zeynep Olgun

and have found that it is complete and satisfactory in all respects,
and that any and all revisions required by the final
examining committee have been made.

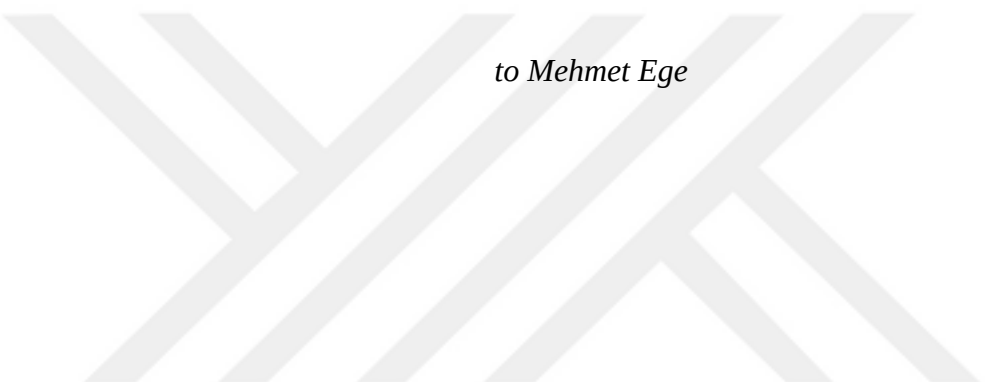
Committee Members:

Assist. Prof. Michael R. Jones

Assoc. Prof. Gnder Varinlioęlu

Assist. Prof. Nikolaos Kontogiannis

Date:



to Mehmet Ege

ABSTRACT

Timber Supply for Byzantine Shipbuilding

Zeynep Olgun

Master of Arts in Archaeology and History of Art

2020

Timber selection for shipbuilding was influenced by many separate factors in the Byzantine Empire. Wood and timber were used as fuel and construction material and were integral to daily life and economy in antiquity. The supply of shipbuilding timber, however, required trees of specific qualities to be felled, and often means to transport them to the shipyards. Written sources such as legal documents, historians' and geographers' accounts, monastic foundational documents (*typika*), and hagiographies, and the material evidence of archaeological wood and pollen data, provide evidence of Byzantine timber exploitation. In recent years, the available evidence of shipwrecks in the Eastern Mediterranean has increased, which provides a new perspective for understanding the Byzantine timber procurement and use. In this thesis, I examine the written and material evidence regarding timber supply for Byzantine shipbuilding from the 4th to 11th century in the Eastern Mediterranean. I give an overview of timber in the written sources and evaluate how much it reveals about the patterns of timber movement in the Byzantine Empire. Furthermore, I discuss the role of shipbuilding timber in politics and naval conflicts in the Eastern Mediterranean. Finally, I evaluate how archaeological material and the shipwrecks contribute to this broader picture, analyzing 45 shipwrecks dating to 4th–11th centuries, recovered from the Eastern Mediterranean. This thesis proposes that the supply of timber for shipbuilding depends on a variety of factors including the environment, the socio-political and economic conditions, as well as the types of timber necessary for the ship to be built.

Byzantine Empire, Middle Ages, shipwrecks, wooden shipbuilding, timber trade, maritime trade

ÖZETÇE

Bizans Gemi İnşasında Ahşap Tedariği

Zeynep Olgun

Arkeoloji ve Sanat Tarihi, Yüksek Lisans

2020

Bizans İmparatorluğu'nda gemi yapımı için ahşap seçimi muhtelif unsurlardan etkilenmiştir. Antik Çağ'da yakacak ve inşaat malzemesi olarak kullanılan odun ve ahşap günlük hayatın ve ekonominin ayrılmaz bir parçasıydı. Ancak, gemi inşasında kullanılan ahşabın tedariki özel niteliklere sahip ağaçların kesilmesi ve genellikle tersanelere taşıma araçlarına gerek duyuyordu. Resmi evraklar, tarihçilerin ve coğrafyacılara kayıtları, manastırların kuruluş belgeleri (vakfiye), azizlerin hayat hikayeleri gibi yazılı kaynaklar, arkeolojik ahşap ve polen verileri gibi materyal kaynaklar, Bizans'ta ahşap kullanımının kanıtlarıdır. Son yıllarda Doğu Akdeniz'deki gemi batıklarının sayısındaki artış Bizans'ta ahşap tedarikini ve kullanımını anlamak için yeni bir bakış açısı sağlamaktadır. Bu tezde, Doğu Akdeniz'de 4. ve 11. yüzyıllar arası Bizans gemi yapımı için ahşap tedarikine ilişkin yazılı ve materyal kanıtların incelenmesi amaçlanmıştır. Öncelikle, yazılı kaynaklarda ahşabın yerini gözden geçirip Bizans İmparatorluğu'ndaki kereste hareketi hakkında ne gibi modelleri ortaya çıkardığı değerlendirilmiştir. Ayrıca Doğu Akdeniz'deki siyaset ve deniz çatışmalarında gemi inşa kerestesinin rolü tartışılmıştır. Son olarak, arkeolojik materyalin ve gemi batıklarının bu geniş resme nasıl katkıda bulunduğunu değerlendirerek Doğu Akdeniz'den çıkarılan 4. ve 11. yüzyıllar arasına ait 45 gemi batığını analiz edilmiştir. Bu tez, gemi inşası için kereste tedarikinin çevre, sosyo-politik ve ekonomik koşullar ve geminin inşa edilmesi için gerekli olan özel kereste türlerini içeren çeşitli faktörlere bağlı olduğunu ileri sürmektedir.

Bizans İmparatorluğu, Orta Çağ, gemi batıkları, ahşap gemi inşası, ahşap ticareti, deniz ticareti

ACKNOWLEDGEMENTS

I would, first of all, like to thank my advisor Dr. Michael R. Jones. He did not only guide me throughout my research with detailed commentary, helpful suggestions and sources, and thus shaping the way I think as a researcher, but he also gave me the priceless opportunity to work on the documentation of Byzantine shipwrecks. I am also very grateful to my thesis committee, Dr. Nikos Kontogiannis and Dr. G nder Varinlio lu for reading and commenting on my thesis, as well as suggesting further research directions.

In my two years at Ko  University Department of Archaeology and Art History, many professors have supported me in the best possible ways. I would like to thank Dr. Matthew Harpster for introducing me to the discipline of maritime archaeology, driving me to Ankara and exceptionally comfortable field work. I would also like to thank Dr. Alessandra Ricci for broadening my perspective of Byzantine Studies. I am also very grateful to Dr. Inge Uytterhoeven, for encouraging me to fill in the gaps of my knowledge on ancient history, and to Dr. Ivana Jevtic for showing me how to appreciate and understand Byzantine art. It is with their inspiration that I continue working on Byzantine Studies. I would also like to thank the GSSSH Administrative Coordinator Tu  e  atana, because she always had all the answers and made my life less difficult. I must express my sincere appreciation to Mustafa V. Ko  Maritime Archaeology Research Center (KUDAR) for my MA fellowship. This thesis has also been supported by Ko  University Suna & İnan Kira  Research Centre for Mediterranean Civilizations (=AKMED) (Project No: KU AKMED 2019/T.1050).

I have spent a lot of time in my academic life in two very different “offices”, at Bilkent and Ko  Universities and I am very happy to have been a part of both. I am thankful to Humberto for correcting my English and the books, Harun and Asad for bearing with me when I talked about my research (although they could not care less) and last but not least, Luca, because indeed, he was always right. I would like to thank my colleagues from the GSSSH office at Ko , for we have suffered together. Nisan, you have been the best field work partner anyone could ask for; Tuna, you have always been there for me when I needed without even questioning, Beril, you have always been the most helpful in the direst situations, and I thank you all for that. For their contributions with translations to this thesis I am grateful for Mert, who did not only check 9th century Kufic

scripts but also 19th century Ottoman documents, Görkem, and Bahattin. This thesis was completed in the most unusual times, as I have written it during the Covid-19 pandemic, in quarantine. I have to thank Ecem Ersözlü, my housemate during this period who did not only put up with me constantly talking about trees, but also always made sure we had enough wine and cake at home for me to maintain my mental health.

Finally, I have to mention my family, especially my mother, sister and my father, thanks to their unconditional support I have never felt alone. And Çağdaş, you are my most brutal critic, but somehow you also manage to be my favorite person. Thank you for always being there for me, on the other side of the phone. This thesis is dedicated to my late grandfather, Mehmet Ege, because unbeknownst to him, receiving “Iliad for Kids” as his gift to me, would one day change my life completely.

TABLE OF CONTENTS

LIST OF TABLES	xi
LIST OF FIGURES	xii
ABBREVIATIONS.....	xiii
Chapter 1: Studying Timber in Byzantium: Old Sources and New Directions	1
1.1 Introduction	1
1.2 Primary Sources for Timber in Byzantine Studies.....	3
1.2.1 Written Sources.....	3
1.2.2 Material Sources and Archaeological Evidence	7
1.3 Approaches to Timber Use in Byzantium.....	13
1.3.1 Scholarship that Focuses Directly to Timber in Byzantium	14
1.3.2 The Aspect of Political Economy	17
1.3.3 The Maritime Perspective	21
1.3.4 Conclusions about the Scholarship	23
1.4 Aim.....	26
1.5 Methodology	27
Chapter 2: Evaluating Trees and Eastern Mediterranean Forests from Material Evidence and Ancient – Medieval Written Sources	29
2.1 Proxy Data for Forest Coverage and Timber Supply	29
2.2 Distribution of Forests in the Ancient Sources	34
2.2.1 Black Sea Coasts of Asia Minor	34
2.2.2 Constantinople and Thrace	35
2.2.3 The Aegean	37
2.2.4 Coasts of Southern Asia Minor.....	38
2.2.5 Cyprus.....	39
2.2.6 The Levant	40
2.3 Exploiting Forests for Shipbuilding.....	43
2.3.1 Forest Exploitation.....	43
2.3.2 Forest Exploitation and Economy of Byzantium.....	45
2.3.3 Acquiring Shipbuilding Timber.....	47
2.4 Shipbuilding Timber in the Ancient Sources	50
2.4.1 Problems with the Identification of Timber Types	52

2.4.2	Theophrastus	53
2.4.3	Pliny the Elder	57
2.4.4	Vegetius	59
2.4.5	The Taktika of Leo VI	59
2.4.6	Geoponika	60
2.5	Deforestation	60
2.6	Logistics of Timber Transport	64
2.7	Timber Prices According to the Edictum de Pretiis Rerum Venalium	68
Chapter 3: The Political Economy of Timber in Byzantium		71
3.1	State Ownership of the Woodland	71
3.2	Woodland Exploitation and Timber Trade in Byzantium in a Chronological Perspective	76
3.2.1	The Persian-Avar Siege of Constantinople	76
3.2.2	The Islamic Navy	77
3.2.3	Emperor John Tzimiskes and the Venetian Doge	82
3.2.4	Restrictions on Mount Athos	84
3.2.5	Further Restrictions on Timber Trade	86
3.2.6	The End of the Byzantine Navy	87
3.2.7	Limits of State Regulation of Timber Movement	88
3.2.8	Conclusion	91
Chapter 4: Shipwrecks and Archaeological Evidence		93
4.1	The Nature of the Evidence	94
4.1.1	Long distance Timber Movement	94
4.1.2	Drawbacks of Dendrochronology	101
	How Does Dendrochronology and Dendroarchaeology Work?	102
	Problems with Dendrochronological and Dendroarchaeological Analysis	103
4.1.3	Shipwreck Origin and the Ethnic Identities of Crews	105
4.2	Shipbuilding in the Mediterranean in 1 st Millennium CE	106
4.3	The Shipwreck Assemblages	115
4.3.1	Mediterranean and Aegean Coasts of Asia Minor	116
	Yassiada II	117
	Yassiada I	119
	Bozburun	120
	Serçe Limanı	121
	Conclusions	124

4.3.2	Levant	126
	Tantura A	128
	Dor 2001/1	129
	Dor 2006	131
	Tantura E.....	132
	Tantura F.....	133
	Ma'aghan Mikhael B	134
	Tantura B	135
	Conclusion	136
4.3.3	Yenikapı.....	137
	Longships.....	140
	Roundships.....	148
4.4	Pitch.....	157
4.5	Joinery	158
4.6	The Theodosian Harbor Samples and Timber Movement	160
Chapter 5: Conclusion		163
Bibliography		173
5.1	Primary Sources	173
5.2	Secondary Sources	176
Appendix A: List of Tree Species in this Thesis (Latin-English-Turkish).....		208
Appendix B: Distribution of Selected Tree Species		210
Appendix C: Glossary of Nautical Terms.....		217
Appendix D: Chronologies		225
	Chronology of Eastern Roman Emperors	225
	Chronology of Important Events in the Eastern Mediterranean	229

LIST OF TABLES

Table 2-1 Timber Prices from the Edict. After Meiggs 1982, 367.....	69
Table 4-1 Selected Shipwrecks from Mediterranean and Aegean Coasts of Asia Minor	116
Table 4-2 Selected Shipwrecks from the Levant.....	126
Table 4-3 Longships Excavated from the Theodosian Harbor.....	142
Table 4-4 Roundships Excavated from the Theodosian Harbor.....	149



LIST OF FIGURES

Figure 1 Summary Interpretation of High-Resolution Pollen and Stable Isotope Data, Nar Lake, 270–1400 C.E. (Haldon et al. 2014, 142.)	31
Figure 2 Major silvicultural techniques in Mediterranean woodlands. a) coppicing b) suckering c) pollarding d) shredding (Di Pasquale et al. 2004, 15.).....	45
Figure 3 Petra Church Mosaic "Camel Carrying a Tree Trunk" (Fiema et al. 2001, 312.)	67
Figure 4 Ship parts labeled on the cross section of L'épave 2 de l'anse des Laurons, 2 nd century CE shipwreck. (Adapted from Gassend et al. 1984, 94.).....	93
Figure 5 Cross-section of oak. (Domínguez-Delmás et al. 2019, 236.)	102
Figure 6 Ravenna, grave stele of Longidienus and Longidiena. (Constable 2005, 173.)	108
Figure 7 Typical mortise-and-tenon joints from Yassiada II c. 375-425 (on the left, pegged) and Yassiada I c. 625 (on the right, unpegged). (After Pomey 2012, 252, 267.)	109
Figure 8 Edge joinery of hull planking from the Late Bronze Age to the late Byzantine period (14 th century BC–11 th century CE). (Pulak 2018, 274).	110
Figure 9 Map of the locations of the shipwrecks discussed in this section.	115
Figure 10 Cross section of Yassiada II shipwreck at midships frame, a wine-glass shaped hull. (van Doorninck 1976, 118).....	118
Figure 11 Sectional view of the port side of the Serçe Limanı shipwreck hull amidships, showing the flat floor timbers and the round turn of the bilge. (Steffy 2004, 160).....	122
Figure 12 Different scarf types commonly seen on Roman and Byzantine ships. After Steffy 1994, 292.....	142

ABBREVIATIONS

A. MKT. NZD	BEO Sadaret Evrakı Mektubi Kalemi-Nezaret ve Devair
AJA	American Journal of Archaeology
AnatSt	Anatolian Studies
BASOR	Bulletin of the American Schools of Oriental Research
BMFD	Byzantine Monastic Foundation Documents
BMGS	Byzantine and Modern Greek Studies
BOA	Başbakanlık Osmanlı Arşivi
BZ	Byzantinische Zeitschrift
CIL	Corpus Inscriptionum Latinarum
DOP	Dumbarton Oaks Papers
Hesperia	Hesperia: The Journal of the American School of Classical Studies at Athens
IGLS	Inscriptions grecques et latines de la Syrie
IJNA	International Journal of Nautical Archaeology
INA	Institute of Nautical Archaeology
INA Quarterly	Institute of Nautical Archaeology Quarterly
J. Anal. At.Spectrom	Journal of Analytical Atomic Spectrometry
JAOS	Journal of the American Oriental Society
JAS	Journal of Archaeological Science
JEA	Journal of Egyptian Archaeology
JFA	Journal of Field Archaeology
JHS	Journal of Hellenic Studies
JRA	Journal of Roman Archaeology
JRS	Journal of Roman Studies
JSAH	Journal of the Society of Architectural Historians
MAAR	Memoirs of the American Academy in Rome
PAPS	Proceedings of the American Philosophical Society
PO	Patrologia Orientalis
sp.	species
TAPA	Transactions of the American Philological Association

TravMém	Travaux et mémoires: Centre de recherche d'histoire et civilisation byzantine, Paris
YK	Yenikapı
Amm. Marc	Ammianus Marcellinus
Artemios, <i>Mir.</i>	<i>The Miracles of St. Artemios</i>
Chron. Pasch	Chronicon Paschale
Cod. Theod.	Codex Theodosianus
De Cer.	De Cerimoniis Aulae Byzantinae
Digest.	Digesta
Diod. Sic.	Diodorus Siculus
Dion. Hal. <i>Ant. Rom</i>	Dionysius Halicarnassensis, <i>Antiquitates Romanae</i>
Dölger	Regesten der Kaiserurkunden des ostromischen Reiches von 565-1453
Edict.	Edictum de Pretiis Rerum Venalium
Eparch	To eparchikon biblion, The Book of the Eparch
Flor.	L. Annaeus Florus, <i>Epitome of Roman History</i>
Greg.	Nicephori Gregorae, <i>Byzantina Historia</i>
Kam.	Ioannis Caminiatae, <i>De expugnatione Thessalonicae</i>
Kantak.	Ioannis Cantacuzeni eximperatoris, <i>Historiarum</i>
Leo VI. Taktika	Leonis imperatoris, <i>Tactica</i>
Lex Rhodia	lex Rhodia de iactu
Luc.	Lucan
<i>Patmos</i>	Βυζαντινά Έγγραφα Μονής Πάτμου II. Δημοσίων Λειτουργιών
Psellos, <i>Chron.</i>	Michael Psellos, <i>Chronographia</i>
Nik. Chon.	Nicetas Choniates, <i>Historia</i>
Ov. <i>Met</i>	Ovid, <i>Metamorphoses</i>
Pl. <i>Criti</i>	Plato, <i>Critias</i>
Plin. <i>Ep</i>	Pliny (the Younger), <i>Epistulae</i>
Plin. <i>HN</i>	Pliny (the Elder), <i>Naturalis historia</i>
Plut. <i>Vit. Demetr</i>	Plutarch, <i>Vitae Parallelae, Demetrius</i>
<i>Prat. Spirit</i>	John Moschus, <i>Pratum spirituale</i>

Procop. <i>Aed.</i>	Procopius, <i>De aedificiis</i>
Theod. <i>An. Av.</i>	Theodore Syncellus, <i>Analecta Avarica</i>
Theophr. <i>Hist. pl</i>	Theophrastus, <i>Historia plantarum</i>
Thuc.	Thucydides, <i>Histories</i>
Veg. <i>Mil</i>	Vegetius, <i>De re militari</i>
Vitr. <i>De arch.</i>	Vitruvius, <i>De architectura</i>
Xen. <i>An.</i>	Xenophon, <i>Anabasis</i>
Zepos, <i>Jus</i>	Jus graecoromanum, eds J. and P. Zepos.



Chapter 1:

STUDYING TIMBER IN BYZANTIUM: OLD SOURCES AND NEW DIRECTIONS

*Arbore sulcamus maria terrasque admovemus.*¹

(Plin. *HN*. XVII. ii. 5)

1.1 Introduction²

When Pliny the Elder wrote that without wood life was not possible, he probably had in mind countless aspects where wood sustained daily life in antiquity (Plin. *HN*. XVII. ii. 5). Trees were used as raw material for various sectors, and it was prominent in large production centers as well as small houses. The foremost need for wood was for fuel and fire. Veal argues that an increase in demand for wood was brought about with the technological advancements during the Roman period, the production sectors of metals, ceramics and glass intensified, which required increased amounts of fuel.³ Daily activities, ranging from household heating to cooking as well as heating large public baths demanded large amounts of wood; in Sagalassos for example, during the Roman imperial period, wood consumption might have exceeded 10 kg per person per day.⁴ In addition, most types of construction, from buildings to harbor and defensive structures required the use of wood either as an integral part or to erect scaffoldings during the period of construction.⁵ Carts and ships – which according to Morrisson, the best known use of wood– were made of timber.⁶ This continued through the Byzantine period with fluctuations of demand. This thesis therefore will be focusing on the supply of timber for shipbuilding during the Byzantine Period (from 4th to 11th centuries) in the Eastern Mediterranean.

The bibliographical format of the *American Journal of Archaeology* was used for this thesis.

¹ We use a tree to furrow the seas and to bring the lands nearer together.

² This chapter is issued from the final paper written for ARHA 509 Modern Historiography of Late Antique and Byzantine Studies taught by Dr. Ivana Jevtic, Spring 2020 at Koç University.

³ Veal 2019, 11.

⁴ Janssen et al. 2017, 598.

⁵ Bouras 2002, 539-52; Bardill 2008.

⁶ Morrisson 2016, 111.

As Haldon states, the primary sources for the study of Byzantium can be divided “notionally into two very crude categories: written, and non-written or material.”⁷ The prevalence of sources depends on the period and region.⁸ For example, the proliferation of written sources depend on different trends of the production of documentary evidence in the empire, such as the number of hagiographical texts increasing from 6th century to the 11th century. When it comes to archaeological finds, they can be discovered accidentally such as many metro line excavations, or be the result of deliberate and planned archaeological projects. Excavations also might end up contributing to a broader research questions than the excavators initially intended; the Serçe Limanı shipwreck, for example, was excavated because the excavators hoped to document an early example of a frame-based Mediterranean ship.⁹ Although the shipwreck (due to its cargo of Islamic glass and other finds) proved to be contributing to many other disciplines and expanded our understanding of Byzantine-Arab relations in 11th century, the main reason for its excavation was initially to illuminate larger trends in maritime technology.

Byzantine studies in the past have relied mostly on written evidence; however, with growing efforts archaeological material has been increasingly included in the discussions, especially regarding the economic, maritime, and environmental studies in the field. Notable excavations in the second half of the 20th century have contributed to the archaeological material. For example, preliminary reports of the Saraçhane excavations in Istanbul were published through the 1960s, with the first final report in 1986 and the second final report focusing on pottery published in 1992, which became an essential source especially for the study of pottery types in Constantinople, and the Byzantine Empire generally.¹⁰ Whittow argued in 1996 that archaeological evidence was crucial for Byzantine studies, calling it the “future” of the field.¹¹ He also pointed out that Byzantine archaeology as a discipline was still not well-developed as a distinct field from classical archaeology, suggesting that “Medieval Byzantine archaeology hardly exists. What is available has largely been obtained as a spin-off from the excavations of classical cities.”¹² The edited volume *The Economic History of Byzantium from the Seventh*

⁷ Haldon 2008, 22.

⁸ Haldon 2008, 23.

⁹ Bass and Van Doorninck 2004, 52.

¹⁰ Harrison and Firatlı 1965, 1966, 1967; Harrison et al. 1986; Hayes 1992.

¹¹ Whittow 1996, 14.

¹² Whittow 1996, 14.

Through the Fifteenth Century utilizes various types of archaeological evidence. In fact, Laiou mentions that in the 21st century, compared to the publication of *The Late Roman Empire* by A.H.M. Jones in 1964, more archaeological data was uncovered for the study of Byzantine economy.¹³ Crow, on the other hand, points out similar concerns as Whittow, noting that although Byzantine archaeological material have been subjected to removal without documentation to reveal earlier periods, there has been a growing trend towards integrating this material by Byzantinists to their work.¹⁴ One of the very recent developments on discussing archaeology in the framework of Byzantine studies, is *The Archaeology of Byzantine Anatolia*, in which various themes, such as urbanism or historical geography, as well as sites that have documented Byzantine settlements, including Nicaea, Sardis and Amorium, are introduced.¹⁵ A broader framework that integrates different types of information and sources in an interdisciplinary manner, as Haldon proposes, would be filling the gaps left open either by written or material evidence in Byzantine history.¹⁶ This chapter therefore outlines major primary sources from which the exploitation and movement of timber can be analyzed, and discusses how these sources have been treated in the scholarship. In the light of this literature review, it also outlines the aim and methodology of this thesis.

1.2 Primary Sources for Timber in Byzantine Studies

1.2.1 Written Sources

It is therefore necessary to have an overview of the primary sources where timber can be traced in the Byzantine Empire, and most of this material will be evaluated in more detail in the following chapters of this thesis. Although this thesis focuses to 4th to 11th centuries and the Eastern Mediterranean (including Asia Minor, the shores of the Aegean, Cyprus, the Levant and Egypt), sources from earlier and later periods as well as wider geographical scope is included as complementary evidence.

As previously stated, primary sources in Byzantine studies can be divided into written and material, and the written material which will be discussed are legal texts,

¹³ Laiou 2002, 8; referring to Jones 1964.

¹⁴ Crow 2008, 47.

¹⁵ Niewöhner 2017.

¹⁶ Haldon 2008, 24.

historical accounts, geographical accounts, hagiographies and *typika*. Legal documents are often concerned with woodland ownership and seafaring. The Theodosian Code (*Codex Theodosianus*) was a compilation and codification of Roman laws under Theodosius II in the 5th century. Several sections concern woodland ownership, such as “Patrimonial farms and woodland pastures; emphyteutic lands and their chief tenants” and “Farms of the privy purse and woodland pastures of the divine imperial household” (*Cod. Theod.* V, 12-13) as well as the supervision of the wood required by the public baths (*Cod. Theod.* XIV, 5). Laws regarding the shipmasters (*navicularii*) are also found (*Cod. Theod.* XIII, 5-9).

Another legal document is the *Rhodian Sea Law*, presumably originated during the Rhodian colonization in the Mediterranean around 750 – 550 CE, and was embedded into the *Digesta* of Justinian in the 6th century, and was adapted into different law codes (such as the *Basilika* in 9th century) and served as the sea law of the empire.¹⁷ This document, gives the monetary value of the ships based on cargo capacities, demonstrating that there was a difference in the value of old and new ships (*Lex Rhodia*, XVI; *Dig.* XIV).¹⁸ Another legal source is the Diocletian’s Price Edict, *Edictum de Pretiis Rerum Venalium* an economic legislation issued by Emperor Diocletian in 301 CE. It contains the prices of different timber types and also standardized sizes for their trade during the Roman period. It therefore is essential to establish to perceived value of various wood types (*Edict*, XII).

It is rare to find timber in historical accounts, but when it is mentioned, it is usually contextualized as a material used in architectural construction or in the construction of warships. Earlier Byzantine historians such as Ammianus Marcellinus (c. 330- c.395 CE), who was a soldier himself, referred to timber in the context of shipbuilding, but not specifically regarding warships (*Amm. Marc.* XIV. viii. 14). Procopius of Caesarea (c. 500- c. 554 CE), although involved in Emperor Justinian’s naval campaigns, mentions timber supply for Justinian’s building activities instead of naval shipbuilding (*Procop. Aed.* V.vi.14-15). In the later period, historians of the Middle Byzantine period put more

¹⁷ Burgmann 1991, 1792; Kurul 2014, 527-8. See Ashburner 1909, lx-cxiv for a detailed discussion about from which manuscripts the Rhodian Sea Law has been compiled.

¹⁸ “A ship with all its tackle is to be valued at fifty pieces of gold for every thousand modii of capacity, and so is to come into contribution. Where the ship is old, it is to be valued at thirty pieces of gold for every thousand modii. And the valuation a deduction is to be made of one third, and the ship is to come into contribution accordingly.” (Ashburner 1990, 63).

emphasis on the use of timber in naval contexts, perhaps due to the increased contentions in the Eastern Mediterranean with the emergence of the Arab navy. References to the Arab raids for timber are found in the *Chronographia* of Theophanes Confessor (759/60–818 CE). The second group of historians that mention timber used for shipbuilding mention it in the context of the Crusades, such as *History* of Nicetas Choniates (c. 1156–1217). Lastly, Kantakouzenos' *Historiarum* should be mentioned again for the accounts of the struggle to find suitable timber for shipbuilding against the Genoese blockage of the Golden Horn in 1348.

One important addition to the historians, who mention timber usage in the narrative of events, are the geographers who have recorded mostly the flora and practices of timber exploitation. In the case of geographers however, the accounts do not have to be limited to the Byzantine period, as earlier and later authors have very similar reflections of the landscape. The general environments of wide geographical areas generally were not altered drastically over short time periods, and most of the geographers' observations are relevant even into modern times.¹⁹ Most of their commentary is observational, and often vague; thus the analysis does not have to be limited to Byzantine authors either. Dunn points out that geographical writings were not a tradition in Byzantine literary writing and thus there is a substantial gap in the source material from Byzantine authors.²⁰ On the other hand, several Muslim geographers, such as ibn-Hawqal (10th century CE) and al-Idrisi (1099-1165 CE) have commented on the arboreal resources around the coasts of the Mediterranean and the Black Sea. In fact, Greek geographer Strabo's (63 BC-23 CE) and Muslim cartographer and geographer Ibn Sa'id's (1213–1286 CE) accounts of timber felling and transportation in the Black Sea coast are very similar.²¹ Thus, the geographers' accounts can be taken together with other sources of evidence, such as tree-rings or lake sediments for ancient climate, regarding arboreal coverage and historic and ethnographic data on timber felling practices. Since Byzantine authors did not produce much on the subject, the evidence does not need to be constrained to them.

¹⁹ Sinop for example, has been described by Strabo (Strabo XII, 3.12) as having vast forested areas by geographers. these forests were evidently exploited by the Byzantines (See Section 2.4.1 in this thesis). Later a Seljuk arsenal was operational in the area (Crow 2017, 395) and forest products from this region was also sent to the capital during the Ottoman period (Faroqi 1984, 76).

²⁰ Dunn 1992, 237.

²¹ Ibn Sa'id quoted in Redford 2014, 91.

There are rare references to trees or timber in hagiographical sources. Efthymiadis and Déroche state that hagiographical accounts were most widely produced between 4th and 7th centuries, and the most prominent mention of trees and timber in such account comes from this period.²² The anonymous Life of Nicholas of Sion was mostly likely the work of one of the saint's disciples in his monastery of St Sion at Akalissos, somewhere in the Lycian mountains north of Myra.²³ Saint Nicholas of Sion, who died in 564 CE was in fact a historical figure, who was ordained as the bishop of Pınara in Lycia.²⁴ The context of the story is the miraculous felling of a demon-infested tree which was used later as the beam of a church. It is not surprising that such a miracle occurred in densely forested Lycia.²⁵ Due to the nature of this genre, most of the references are intertwined with miracles or supernatural beings, but they reflect social and economic norms, and beliefs, as well as how the society interacts with its natural surroundings, such as how timber was acquired and transported.

The last category of the written sources that should be mentioned is the monastic foundation documents, *typika*. These documents, which were not strictly “foundational” as they could be issued at any time, could also be wills, decrees and rules, and some primarily had a liturgical character.²⁶ Overall, *typika* reflect various aspects of monastic life in Byzantium between 8th and 15th centuries. Several of these documents refer to timber, and different regulations can be traced from the updated decrees. For example, in the *typikon* of Emperor John Tzimiskes dating to 971–72, the Athonite Monasteries are banned from selling firewood outside of the mountain (24).²⁷ On the *typikon* of Emperor Constantine IX Monomachos issued in 1045 expands this ban to “lumber for building, thin planks, firewood, and pitch” and decree that if one is caught doing such act, their boat will be taken (6).²⁸ A similar issue is found in the two chrysobulls in the *Rule* of Michael Attaleiates for his Almshouse in Rhaidestos and for the Monastery of Christ *Panoiktirmon* in Constantinople from Emperor Michael VII Doukas (1075) and Nikephoros III Botaneiates (1079), both preventing “the cutting and transport of any sort

²² Efthymiadis and Déroche 2011, 35.

²³ Efthymiadis and Déroche 2011, 69.

²⁴ Ševčenko and Ševčenko 1984, 11.

²⁵ Ševčenko and Ševčenko 1984, 135.

²⁶ Thomas et al. 2000, xi.

²⁷ Thomas et al. 2000, 240.

²⁸ Thomas et al. 2000, 287.

of wood or the transport of oars, or anything else.”²⁹ These documents illustrate the involvement of the monastic institutions with the trade of wood and timber in the empire, and the extent of the emperor’s attempted control over their transactions.

In addition to this material, there are several sources that have more detailed information on shipbuilding timber. The earliest of them is Greek botanist Theophrastus’ (c. BCE 371– 287) *Historia plantarum*, talking explicitly about which timber should be used for different parts of a ship (Theophr. *Hist. pl.* V.vii.1-8). From the Roman period two authors, Pliny the Elder’s (c. 23–79 CE) *Naturalis Historia* (Plin. HN. XVI. Xviii.41-2; lxxv.195) and Vegetius (4th century CE) *De Re Militari* also outline suitable tree types for naval shipbuilding (Veg. *Mil.* IV.34).

Some of the main textual sources therefore, where references to timber can be found have been outlined. However, as Haldon proposes, “Archaeological investigation is essential to any balanced picture of Byzantine economic and social history.”³⁰ Thus, the current archaeological evidence should be discussed to attempt to compliment the broad picture of timber in Byzantium.

1.2.2 Material Sources and Archaeological Evidence

Remains of wood can be found in several archaeological contexts, as small objects, charcoal, or architectural remains such as architectural timber; in the different states of dry, charred, waterlogged, subfossil, and fossilized.³¹ These have been recovered from systematic archaeological excavations or as accidental finds dating to the Byzantine period. Remains of wooden coffins for example have been recovered from salvage excavations from a necropolis in Ankyra dating to the early Byzantine period.³² Wooden plates and spoons were found as cargo on one YK 1 shipwreck excavated from the Theodosian Harbor.³³ Charcoal have been recovered from many different sites, such as Sagalassos and tree species can also be identified from them.³⁴ Timber tie beams survive in several buildings: the primary construction phase timbers of Hagia Sophia and Hagia

²⁹ Thomas et al. 2000, 262, 266.

³⁰ Haldon 2008, 26.

³¹ Lev-Yadun 2007, 142.

³² Arslan and Aydın 2011, 305-11.

³³ Baran Çelik 2007, 227. See Gökçay 2010, 135-52 for selected wooden finds from Yenikapı.

³⁴ Vermoere 2003.

Irene in Constantinople are still preserved in the buildings.³⁵ There are therefore plenty of samples of wood and timber, although not all of them might be suitable for analysis such as dendrochronological investigations due to their species, size, part of the tree from which they came, or preservation level.

The possible movement of timber around the Mediterranean on the other hand can be explained in at least two ways. To start with, shipwrecks and their cargoes as well as many imports found on archaeological sites attests to trade by sea during the Byzantine period.³⁶ For example, in Serçe Limanı shipwreck dating to 11th century found in the coast of Marmaris, 56 Günsenin type I amphoras were found, whose fabric points to a production in the Ganos kilns along the shores of the Sea of Marmara.³⁷ YK 12, a shipwreck recovered from the Theodosian Harbor also had Günsenin type I amphoras in its cargo.³⁸ This evidence points to both long distance and regional trade of Ganos wine during the Byzantine period, and is a small example of various trade goods that circulated by sea. Secondly, cargoes of timber for shipbuilding are rarely recovered from shipwreck sites, but indirect evidence exists which can be interpreted as long distance timber trade, which is discussed in more detail in Section 4.1.1 in this thesis.³⁹

This thesis also aims to integrate the evidence from nautical archaeology to the field of Byzantine studies. Nautical archaeology essentially is the archaeology of the ship (*naus*), and according to Bass, that ship could be found land, under water, partly on land and partly under water, or in some cases still afloat.⁴⁰ He also argues that since the ship cannot be separated from “its home”, and thus port and harbor studies must also be considered a part of nautical archaeology.⁴¹ This can be illustrated with the Yenikapı excavations, the project lasting from 2004 to 2013 which revealed the Theodosian Harbor

³⁵ Kuniholm et al. 2015, 75.

³⁶ For a general discussion see McCormick 2012.

³⁷ Günsenin 2009, 147.

³⁸ Günsenin 2009, 150.

³⁹ Timber for small objects have been recovered, one example can be the cargo of boxwood logs on the Roman shipwreck dating to 1st century BCE at Comacchio, where the boxwood pieces were on average 276 years old and 17 cm in diameter, See Ulrich 2007, 245.

⁴⁰ Bass 2011, 5.

⁴¹ Bass 2011, 5. Maritime archaeology in general has been defined as “the scientific study of the material remains of man and his activities on the sea” (Muckelroy 1998, 24) However, since the sea and the inland waters are also connected, the term maritime can be broadened to “include inland waters, lakes, rivers and estuaries, as well as the seas and oceans” (McGrail 1989, 10). Nautical archaeology then is a sub-discipline of the general maritime archaeology, although these terms are often used interchangeably by authors.

of Constantinople, where an assemblage of approximately 37 Byzantine ships have been recovered, variously dating between the 5th and the 11th centuries.⁴² Both the ships and the data from the harbor itself such as wooden pilings has contributed to the understanding of daily life in Byzantium.

McCormick suggests that “One of the single most expensive capital goods in the ancient economy, ships constitute a key chapter in economic history even without their cargoes.”⁴³ This is especially true in the context of timber supply: the ships themselves are valuable evidence to understand the use and movement of timber. Around 80 identified shipwrecks dating to the Byzantine period were published by Parker in 1992, and this number has increased with the surveys in later years.⁴⁴ Most of these shipwrecks does not have recorded hull remains and/or have not been excavated and published. There are around 50 shipwrecks dating between the 4th–11th centuries that have been excavated or documented enough to allow a discussion of construction materials and techniques.⁴⁵ In the context of this thesis, various shipwrecks from the Mediterranean will be discussed, including several relevant shipwrecks from earlier or later periods. However, the finds from the Eastern Mediterranean region, dating to between 4th–11th centuries will be included in a detailed analysis. These shipwrecks have substantial hull remains which been documented and published with the identification and analysis of the tree types used in their construction. In this regard, the 45 shipwrecks from specifically the Eastern Mediterranean that will be included can be divided into three geographical regions in accordance with their find spots: Mediterranean and Aegean Coasts of Asia Minor, the Levant, and the Sea of Marmara. Although in varying degrees, the wood that was used in the construction of these shipwrecks have been identified and published. In the publications of these reports, the types of wood that were selected by the shipwrights have been discussed mostly in the context of which part of the ship they have been used and the performance or anatomical qualities of the timber types.⁴⁶ These publications (many of them are preliminary) often aim to report and analyze the material evidence in the

⁴² Pulak 2007; Kocabaş 2008.

⁴³ McCormick 2012, 79.

⁴⁴ Parker 1992. For example, for the recent surveys on the Western Asia Minor coasts see Özdaş 2007, 2009a, 2009b, 2010, Özdaş, Kızıldağ and Okan 2012 as well as Leidwanger 2017, 2020 110–22.

⁴⁵ For a survey of these shipwrecks see Pomey et al. 2012 and Pulak 2018.

⁴⁶ Akkemik 2015, Akkemik and Kocabaş 2013; Akkemik and Kocabaş 2014; Liphshitz 2009; Liphshitz 2012a; Liphshitz 2014a; Liphshitz 2014b; Liphshitz and Pulak 2007/2008; Liphshitz and Pulak 2009. See also the individual final reports of shipwrecks in which analysis of timber is also included.

context of nautical archaeology, therefore other subjects that affect wood supply—such as the structure of economy and trade routes, the patrons or contractors, military or civil nature of the endeavors—have not been discussed extensively. However, these discussions are beyond the scope of preliminary reports. The chronological and regional comparison of these shipwrecks from the perspective of the timber that was used in their construction may be revealing about the geographical differences and developments in Byzantine shipbuilding as well as the movement of timber around the empire.

These samples which come from various timber finds; buildings, piers, defensive walls, charcoal, or shipwrecks have often been analyzed with dendrochronological methods. Dendrochronology is a scientific method used to date tree rings to the year that they were grown.⁴⁷ If trees are in the same climatic region, they are affected by the climate (mostly changes in rainfall and temperature) in the same way, their growth rings can be cross dated with one another, placing them in a common chronology.⁴⁸ It is an absolute dating method, and if the sample is suitable, it can be dated to a specific calendar year.⁴⁹ Since 1973, more than two hundred medieval buildings in Greece and Turkey have been sampled for dendrochronological analysis in the scope of the Aegean Dendrochronology Project.⁵⁰ With this method, trees that grew in the same climatic region can also be potentially identified, which can point to a particular forest as a source for dispersed timber finds, as well as different forest dynamics such as fires and parasites. For example, it was recently demonstrated that the wood samples taken from a Roman fort in Capidava, Romania was coming from the same source as several of the wooden piles at the Theodosian Harbor.⁵¹ Tree-rings have also been used to reconstruct ancient climate, especially precipitation values.⁵² Kuniholm et al. has also discussed timber in the context of trade.⁵³

Dendrochronology is possible with enough evidence, certain amount of tree rings must be present from the sample, and a master chronology to cross date the sample to

⁴⁷ Schweingruber 1988, 96; Baillie 1997, 16-7.

⁴⁸ Kuniholm 2001, 1; Kuniholm 2008, 182.

⁴⁹ Kuniholm 2008, 182.

⁵⁰ Kuniholm and Striker 1987; Kuniholm et al. 2007, 365, 376-85.

⁵¹ Wazny et al. 2017, 180.

⁵² See for example Griggs et al. 2014 for precipitation reconstruction and drought assessment for Cyprus from *Pinus brutia* tree-rings.

⁵³ Kuniholm et al. 2007; Kuniholm et al. 2015.

(this method is discussed in detail in Section 4.1.2). If the bark or the surface right under the bark is present (the waney face), the felling date of the tree can potentially be determined to the year, and Kuniholm has observed that during the Byzantine period around the Aegean, most of the trees were used in the year that they were felled.⁵⁴ This even helped correcting the misdating of Byzantine monuments, such as the Church of the Holy Apostles in Thessaloniki, where the original construction of the church was moved to 1329 or later, at least 15 years after the inferred date from the founder's inscription.⁵⁵ The excavations at the Theodosian Harbor for example have contributed to the establishment of a 2367-year long oak chronology.⁵⁶

In addition to the dating of the timber, if enough samples are collected, dendrochronology can be useful to understand the source of wood as well. Further investigations in this topic have been undertaken in different parts of Europe, and were especially successful in Northern Europe. The Newport Medieval Ship –a fifteenth century merchant vessel unearthed in Britain– for example, have been dated and provenanced with dendrochronological analysis, the felling of the timbers were dated to 1449 and sourced from the Basque region of northern Spain.⁵⁷ Another example are the Skuldelev ships, Viking vessels that were sunk in Roskilde. From this group for example, the dendrochronological analysis showed that the keel of Skuldelev 2 was made from a tree felled in 1042, in the Dublin region.⁵⁸ Regarding the dendrochronological analysis of the Karschau Ship dating to 12th century CE, Daly proposes that it was “possible to differentiate between small regions of timber sources for shipbuilding.”⁵⁹ It is however not possible to have similar chronologies for the Mediterranean yet. Guibal and Pomey, for example, discuss the dendrochronological analysis of 27 ancient shipwrecks recovered from the coasts of southern France, however pointing out the problems of creating master chronologies in this region.⁶⁰ A detailed research was also done by Rival on Roman shipbuilding from a perspective of timber supply and use, focusing on two shipwrecks off the coasts of France.⁶¹ However, there have also been significant

⁵⁴ Kuniholm 2008, 184.

⁵⁵ Kuniholm and Striker 1990.

⁵⁶ Kuniholm et al. 2015.

⁵⁷ Nayling and Suspereggi 2014.

⁵⁸ Pomey 2011, 41. See Crumlin-Pedersen and Olsen 2002.

⁵⁹ Daly 2007, 155.

⁶⁰ Guibal and Pomey 2004, 35.

⁶¹ Rival 1991.

developments in the use of strontium isotopic analysis to determine the provenance of archaeological cedar wood in the Eastern Mediterranean.⁶²

Another issue that will be covered in the context of this thesis is the indications of ancient forest coverage. The forest coverage is related to various factors, such as geology, topography, climate, and soils, Veal argues that “the influence of the environment on wood resources cannot be understated” because it is essentially the geological and climatic conditions which determine the wood sources.⁶³ In order to discuss this, evidence for land use, agriculture, arboriculture, and general settlement patterns and climate should be analyzed. Palynology, for example which is discussed in more detail in Section 2.1, can reveal about the paleoenvironment, diet, subsistence, disease, and the level of technology and trade of a society.⁶⁴ Some trees are more sensitive to the changes in climate, especially shifts between wetter and drier phases, thus the recent upsurge in the studies of ancient climate contributes to our understanding of forest coverage as well.⁶⁵ Oxygen isotope research for example contributes to the understanding of climate as well, it was observed for example that between 561–801 CE there was an increase in snowmelt in Asia Minor, showing changes in climate which affect the distribution of tree species.⁶⁶

Izdebski has analyzed more than twenty sites where pollen cores have been taken in Asia Minor since 1970s in regional basis.⁶⁷ One distinctive pattern has been identified in the pollen diagrams from southwest Asia Minor, a period of increased anthropogenic activity which has been called the Beyşehir Occupation Phase.⁶⁸ During this period, which lasts approximately between 1450 BCE and 600 CE, there was extensive land clearance and agriculture, which ends around the beginning of the 7th century when woodlands regenerate, with pine being the dominant forest tree.⁶⁹ This data is not limited to this site, but it correlates with other cores from the Eastern Mediterranean region, thus pointing to a general trend during this period. This phenomenon is especially crucial for

⁶² Rich et al. 2008, 2012, 2016.

⁶³ Veal 2017, 231.

⁶⁴ Bryant and Holloway 1983, 191.

⁶⁵ Haldon et al. 2014 outline how proxy data regarding climate change should be used in historical research. Izdebski and Mulryan 2019 outlines the climatic changes in Late Antiquity.

⁶⁶ Dean et al. 2013.

⁶⁷ Izdebski 2013.

⁶⁸ Eastwood et al. 1998, 70.

⁶⁹ Eastwood et al. 1998, 70. This is discussed in detail in Section 2.1 in this thesis.

the study of timber in Byzantium as it presents evidence for the forest coverage and anthropogenic affects. Some data in this regard has been integrated into the discussion of wood and timber demand and supply. A prominent example is studies related to the Sagalassos region, where evidence for vegetation during the Early Byzantine period has been analyzed in relation to the fuel needs of the city.⁷⁰ However, reports from these sites or individual projects often remain exclusive to the analysis of the site and the surrounding regions under scrutiny, and does not contextualize the finds in a wider geographical scope, or with a comparative perspective. Izdebski has discussed this body of data in a comparative perspective for Asia Minor from Late Antiquity to the early Middle Ages in detail.⁷¹ It can be seen that the trend is towards integrating site and region specific data to a wider discussion of economy, climate and historical narratives. In addition to this, although not a direct parallel to the Byzantine Period, modern forest habitats can give clues about the ancient forest coverage, habitat, and range of particular species, especially if analyzed with the pollen evidence. However, the drawbacks of these methods should not be understated. Pollen analysis for example requires samples from specific geological deposits, such as undisturbed lake sediments where they are preserved longer.⁷²

1.3 Approaches to Timber Use in Byzantium

Timber use may be studied using a wide range of textual and material sources, and scholars have discussed the topic from different points of view and utilizing different evidence. Therefore, this section will not take a chronological direction in analyzing them, but the scholarship will be grouped in their main perspectives on timber. Before focusing on the scholars that concentrate on Byzantine studies or related time periods, however, Russell Meiggs' *Trees and Timber in the Ancient Mediterranean World* published in 1982 must be discussed.⁷³ In his work, which focuses on various aspects of timber exploitation, movement and use in the Ancient Mediterranean, Meiggs' chronological scope expands from the Bronze Age when Egyptian ships were made by cedar imported from Lebanon, to the Roman Empire. He mainly analyses ancient primary

⁷⁰ Vermeore et al. 2003; Janssen et al. 2017. For the recent studies of timber sources around Sagalassos see Muys 2019.

⁷¹ Izdebski 2013.

⁷² Izdebski 2013, 110.

⁷³ Meiggs 1982.

textual sources: botanical, historical, and geographical texts, chronicles, treatises, and inscriptions. He thematizes his work and mentions a wide range of the use of timber, from the wood necessary for the fleets of Athens, to furniture and sculptures. One of the most important contributions of his work is the analysis of the ancient terminology of different tree species and the problems that are created by the use of the different words for the same tree or one word referring to various species.⁷⁴ He focuses more on documentary rather than archaeological evidence and this publication remains the most comprehensive survey of the textual ancient sources regarding timber in the Mediterranean. It is not a crucial component of timber studies in Byzantium *per se* as his chronological framework does not go beyond the Roman period. However, in the Mediterranean region which he focuses on, the conditions were likely similar to the periods that he discusses which makes his work very relevant to studying timber in the Byzantine Empire.

1.3.1 *Scholarship that Focuses Directly to Timber in Byzantium*

Three contributions by Byzantine historians can be highlighted for focusing directly to timber exploitation and trade in Byzantium. The most extensive ones in this regard is perhaps Archibald Dunn's two articles, "The Exploitation and Control of Woodland and Scrubland in the Byzantine World" and "The Control and Exploitation of the Arboreal Resources of the Late Byzantine and Frankish Aegean Region."⁷⁵ As can be understood from the titles, his work mostly concentrates on the landscape, woodland and scrubland coverage and the exploitation of forest resources. He is not necessarily concerned with the demand of wood from different industries, and he does not constrain himself only to wood, but surveys the exploitation of various forest by products such as pitch, kermes and mastic. Dunn argues that the evidence from the Byzantine period for the exploitation of forest resources is scarce but there is a historical continuity of silvicultural practices in the Eastern Mediterranean; thus a long-term perspective should be taken with the contribution of ethnographic studies.⁷⁶ Timothy Insoll concurs, stating that although ethnographic analogy does not provide direct evidence, it "enables scholars in the present to consider possibilities for understanding the past."⁷⁷ As mentioned, the integration and

⁷⁴ Meiggs 1982, 410-22. "Appendix 3 Confusion of Species on the Greek and Latin"

⁷⁵ Dunn 1992; 1996.

⁷⁶ Dunn 1992, 250.

⁷⁷ Insoll 2007, 48.

discussion of the archaeological approaches to Byzantine Studies have started to developed in late 20th century; and Dunn's paper is also interdisciplinary, utilizing both archaeological as well as textual evidence. He devotes a large section to pollen analysis and dendrochronological investigations. Although new data has been collected since the publication of this article, it is significant that Dunn integrated environmental data into his analysis. From the arboreal pollen values, he proposes an advancement of rural settlement and retreat of woodland in Antiquity, and the reverse in Early - Middle Byzantine period lasting to 1000 CE especially for Greece, Cyprus and Southern Anatolia.⁷⁸ In addition to archaeological and ethnographic sources, he makes use of a variety of texts, these include Diocletian's Price Edict –which he emphasizes to be from Late Antiquity–, the *Geoponika*, the Theodosian Code, Byzantine military treatises and historians such as Anna Komnena and Niketas Choniates. For later periods, which are characterized by increased interactions with the Latin West, he also utilizes “the charters, the notarial acts of foreign merchants.”⁷⁹ Dunn also includes the writings of geographers, however underlines that this type of evidence is often from Arabic sources such as el-Idrisi.⁸⁰

Overall, he suggests that it still cannot be determined the extent of local demographic pressure at the subsistence level, and to what extent the pressures of the market and the general demand had over woodlands.⁸¹ In earlier periods, he argues, the exploitation and regulation of woodlands were due to strategic concerns, which in the Late Byzantine Period were replaced mostly by the fiscal needs of the state. This change is connected to the loss of woodlands and shifts of political power in the empire from the Byzantines to Latins. In the 1996 chapter “The Control and Exploitation of the Arboreal Resources of the Late Byzantine and Frankish Aegean Region”, Dunn relies heavily on his earlier work for the general introduction to woodland exploitation. Compared to his earlier work, this chapter –indicated by its title– is geographically constrained to the Aegean region, and the evidence from the Latin sources, such as mercantile charters are more prominent.

⁷⁸ Dunn 1992, 247. See Section 2.1 in this thesis for the discussion of arboreal and nonarboreal pollen data.

⁷⁹ Dunn 1996, 483.

⁸⁰ Dunn 1992, 257.

⁸¹ Dunn 1992, 243.

These articles are essential examples of integrating both textual and archaeological evidence to the study of timber.

Aside from Dunn, Cecile Morrisson's chapter "Trading in Wood in Byzantium: Exchange and Regulations" also focuses solely on timber.⁸² Morrisson, who is a numismatist, studies wood from the economic perspective and in the context of trade. She argues that timber is "an essential but elusive and rather neglected subject" and although wood is an "invisible" element, it has a potential of contributing to the field of Byzantine trade and economy.⁸³ Although her chapter does not necessarily have an overarching argument as it is an introduction to the topic, it consists of overviews of demand, production and trading of wood where she details the prices, regulation and direction of the trade. Morrisson relies heavily on documentary sources. These includes several monastic foundation documents, *typika* such as of the Pantokrator Monastery from the 12th century, or Julian of Ascalon's "Treatise of Construction and Design Rules," which was composed in sixth century Palestine in regard to instituting preventative measures against fires in the city due to the prevalence of wooden housing.⁸⁴ Hagiographies such as the life of St. Nicholas of Sion are cited, retelling the story of the tree that was frequented by a demon.⁸⁵ An important contribution of Morrisson is the calculation of the timber that was used by –for example– Constantinople in the 5th to 6th centuries with an approximate of 400.000 inhabitants; which is a minimum 236,000 tons of wood for fuel.⁸⁶ These estimates, although not certain, illustrate the high demand of wood. Information on the areas that supplied this wood, come from travelers' or geographers accounts, and later Latin archives are also cited as sources for timber trade. Although Morrisson makes some use of archaeological evidence, such as the dendrochronological work undertaken on the al-Aqsa mosque's beams or the results that the Yenikapı excavations have produced, such evidence is emphasized less when compared to the extensive coverage of the textual sources. The variety of the latter however shows that timber in Byzantium can be traced from textual sources but requires the assembling of scattered references in a meaningful manner, either chronologically, or

⁸² Morrisson 2016.

⁸³ Morrisson 2016, 106, 122.

⁸⁴ Morrisson 2016, 109; for the analysis of this treatise see Hakim 2001, 4-25.

⁸⁵ Morrisson 2016, 109-10.

⁸⁶ Morrisson 2016, 108.

thematically as Morrisson does. Morrisson concludes with the prospect of integrating the further analysis of the timber finds from the Yenikapı excavations in Istanbul to place timber in the economic history of Byzantium.⁸⁷

As studies from the mainstream Byzantine scholarship focusing on only timber and arboreal products, Dunn and Morrisson's contributions focus specifically on woodland exploitation and its economic role. Both use mainly textual sources to illustrate the movement of timber in the empire, although the sources might be from outside the empire, such as Arab geographers; or from other time periods, such as the Ottoman records of practices in the same geographical regions after the fall of the Byzantine Empire. In addition to these, Dunn especially makes use of available archaeological and environmental data, and he also states that a balance between "archaeologically led surveys and archival studies" should be found.⁸⁸ There is in fact more archaeological evidence since his work was published in 1992. The works discussed so far focus mostly on forest resources and their place in the economy, but there are other publications that also mention timber, in various contexts of diplomacy, or naval and maritime history, which must be discussed in order to understand the role of timber in the broader studies of Byzantine Empire and the Mediterranean.

1.3.2 *The Aspect of Political Economy*

Timber was a strategic material as it was used for building warships and weapons, thus it has been analyzed in the context of political economy and history. When it comes to the approaches especially to trade in the Medieval Mediterranean, the fundamental assertion was the "Pirenne Thesis", which essentially argues that the unity of the Mediterranean, especially in the context of trade, was cut in the 7th century with the entrance of the Muslim naval powers to the region.⁸⁹ Lewis surveyed the period between 500–1100 CE in *Naval Power and Trade in the Mediterranean* and have argued for the same result but with a different culprit, and suggested that it was the Byzantine naval revival of the 8th century which interrupted the Arab trade with the West, thus destroyed the ancient unity of the Mediterranean.⁹⁰ A similar overview was done by Eickhoff,

⁸⁷ Morrisson 2016, 122.

⁸⁸ Dunn 1992, 236-37.

⁸⁹ Originally published in 1939, Pirenne 2008, 284.

⁹⁰ Lewis 1951.

Seekrieg und Seepolitik zwischen Islam und Abendland, about politics, naval strategy, and warfare based on the documentary sources between 650–1040.⁹¹ However, one of his points was that although there was piracy or naval warfare in the Mediterranean after the 7th century, the trade and movement of people have continued.⁹² These works were based primarily on documentary evidence. Unger's book *Ship in the Medieval Economy 600-1600* which was published about fifteen years after also utilized textual sources in its discussion, from which he contextualizes developments of ship design from an economic perspective. Although he approaches the issue from a fiscal perspective where his main concern is the economy, he does not give detailed explanations about the timber supply for shipbuilding. His discussion on this topic also only refers to the works of Hélène Antoniadis-Bibicou and Maurice Lombard and not the primary sources.⁹³ On the other hand, he has recently (2015) pointed out the new evidence gathered from archaeological data in the last thirty years, especially McCormick's work on European economy.⁹⁴ He supports that long-distance trade continued even after the 7th century, and trade was continuous and stable.⁹⁵ He had previously applied the Pirenne perspective to his discussion of trade in the Mediterranean and argued that after the conquest of Crete by the Arabs in 9th century "The Mediterranean became a no man's land between Christian and Muslim naval forces with Crete as a base for pirates."⁹⁶ However, naval contentions and piracy –as previously stated by Lewis– was not the end of long distance trade. Horden and Purcell, for example, argue that evidence for piracy is an evidence for persistent exchange, as pirates both had to feed from merchant shipping, and they also have contributed to the movement of goods as even the stolen goods and slaves often had to be resold at a different port.⁹⁷

The interpretation of timber trade in this framework largely depends on the fact that the Muslims often had limited forest resources suitable for shipbuilding.⁹⁸ The territorial extensions of The Caliphate of Damascus (660-759) and Baghdad (750-1258) or the

⁹¹ Eickhoff 1966.

⁹² Eickhoff 1966, 48-50.

⁹³ Unger 1980, 55 n. 21.

⁹⁴ Unger 2015, 5-6, referring to McCormick 2001.

⁹⁵ Unger 2015, 7-8.

⁹⁶ Unger 1980, 96.

⁹⁷ Horden and Purcell 2000, 157-58.

⁹⁸ Canavas 2007, 607-8. Having access to woodlands did not always mean having access to timber suitable for shipbuilding, as especially warships required certain lengths and widths of timber that could only be supplied by specific tree species.

Fatimid State (909-1171) to name a few, lacked forests with trees of the quality and amounts to build fleets. Therefore, the main aspect of this research revolves around the triangular movement of timber between the Arabs, Byzantines, and the Latins, which was either facilitated or restricted by these three political powers around the Eastern Mediterranean.

Two works of Maurice Lombard focus on the timber needs of the expanding Arabs from the 7th century onwards. “Arsenaux et bois de marine dans la Méditerranée musulmane, VIIe-Xie” and “Un problème cartographié : le bois dans la Méditerranée musulmane (VII e-XI e siècles)” published in *Annales* in 1959 were detailed analyses of primary sources.⁹⁹ Lombard in both works argues that the geography which the Arabs were controlling starting from the 7th century did not have vast forested areas and the ones they had were rapidly deteriorating into *maquis* habitats, which are not suitable for growing timber for shipbuilding. Therefore, the struggle between the Caliphate and the Byzantines were over the timber sources required for both warships and merchant ships. Although his works are an important contribution especially with the integration of primary Arabic sources, his argument about demand for timber doubling in the Mediterranean with the entrance of the Arab navy is possibly an over-estimate by the author based on primary sources.¹⁰⁰ His comments about ship capacities and the supposed increase of timber required to build bigger ships in the Mediterranean is not supported by archaeological and textual evidence, although it can perhaps be argued for the later Medieval period in regard to Western Mediterranean or northern European ships.¹⁰¹ Lombard argues that the Islamic world suffered from a shortage of wood, partly from natural scarcity, but partly also the result of nomadism and unchecked urban exploitation. Harkening back again to the Pirenne thesis, he argued that the abundance of marine timber in the “barbaric” West, scarcity in the Muslim countries was the reason why the domination of the sea and the driving centers of the great maritime trade passed from the Muslim to the Christian Mediterranean.¹⁰² Horden and Purcell, on the other hand, who also touch upon the timber sources in their work *The Corrupting Sea*, argue that with the

⁹⁹ Lombard 1959a; Lombard 1959b.

¹⁰⁰ Lombard 1959a, 57.

¹⁰¹ McCormick 2001, 96 also mentions that most ships after the Late Empire were smaller than 75 tons of cargo capacity.

¹⁰² Lombard 1959a, 98-9.

complexity of network connectivity around the Mediterranean, statements “grand and simple” such as Lombard’s can be disregarded.¹⁰³ Although an important contribution to the field with the integration of Muslim geographers and chroniclers, Lombard’s work falls short of an in-depth analysis, especially due to the lack of archaeological and environmental evidence available during the 1950s and 60s.

Most of these works were published in the mid-20th century and discuss with similar reservations about the trade between the Muslim and Christian Mediterranean in two different blocks. David Jacoby on the other hand highlighted a more complex network of trade during this period, “Byzantine Trade with Egypt From the Mid-Tenth Century to the Fourth Crusade” published in 2000 and “The Supply of War Materials to Egypt in the Crusader Period” published in 2001 refer to especially the trade of timber in the Eastern Mediterranean. In the first article, the author lists three arguments that the Byzantine scholarship put forward regarding the economy: they believed that the empire was self-sufficient, and the state did not give incentives to foreign trade. He then goes on to argue that this was not the case of trade with Egypt, which was still flourishing after its Muslim conquest, suggesting that the trade in the Eastern Mediterranean was triangular between the Byzantine Empire, Egypt and the West, based on textual sources, focusing on the continuation of this flow.¹⁰⁴ As an example Jacoby mentions Ibn-Hawqal’s testament to the shipping of timber from Southern Asia Minor to Egypt in the 10th century, as well as the archival material from the Western sources, mostly concerned with bans on the trade of timber to the Islamic caliphate. These bans, on the other hand, are elaborated upon in his latter article on war materials.¹⁰⁵ Timber, especially for shipbuilding, along with iron and pitch, are considered by the surviving documents and Jacoby to be war materials, and Egypt’s scarcity did force the rulers to import it from elsewhere.¹⁰⁶

Chronologically his article investigates the crusader period, and traces from both the Arabic and the Western sources; Amalfitan, Pisan, Venetian, and Genoese timber traders in Egypt. Just as the Byzantines have occasionally banned the trade of timber to the Muslims, the same practices were in place for the Western states. This not only shows

¹⁰³ Horden and Purcell 2000, 336.

¹⁰⁴ Jacoby 2000, 35-7.

¹⁰⁵ Jacoby 2001.

¹⁰⁶ Jacoby 2001, 102.

that naval timber was a valuable and strategic commodity, but also that its trade was in such quantities that it required regulation. Still, Jacoby points out that although there were several bans in place, most of the accounts are of ships that were seized and fined during illegal shipments, pointing out that timber trade was so lucrative that merchants were taking the risk of facing these repercussions, or the bans themselves were not being taken seriously, or were not enforceable.¹⁰⁷

1.3.3 *The Maritime Perspective*

Although most of the works on timber in Byzantium is embedded into the discussion of political economy and trade, works on seafaring, shipbuilding and naval administration has touched upon the topic as well. The most extensive book on naval history of Byzantium that is focused extensively on the Empire was published in 1966 by H  l  ne Ahrweiler, titled *Byzance et la Mer. La marine de guerre, la politique et le institutions maritimes de Byzance aux VII-XV si  cles*. This work which covers from 7th to the 15th centuries and focuses mostly on administrative aspects of the “maritime matters” of Byzantium, from the organization of the naval themes to the naval expeditions to Sicily and Crete. Ahrweiler’s work depends on an analysis of textual and archival sources, such as lead seals, monastic documents, and hagiography as well as historical works and military treatises and other documents regarding naval affairs. She is often concerned with the timber supply for the navy; referring to Niketas Choniates, Ahrweiler argues that Byzantium has never lacked technical staff and material resources (for which she includes pine and cypress) required for shipbuilding: it could easily find them in many regions of the empire (mostly, however, from the maritime themes).¹⁰⁸ She proposes that the arsenals would be relocated when the previous location was compromised by the enemy, for there were many protected harbors and ports in Byzantine territory.¹⁰⁹ When it comes to the transportation of timber, however, she proposes that there are no sources mentioning this movement, asserts that “Le bois   tait surtout un souci pour les Arabes.” Since timber was the “problem” of the Arabs, obtaining it was one of the main objectives of their incursions to Syria and Asia, which she proposes, relying on the works of

¹⁰⁷ Jacoby 2001, 129.

¹⁰⁸ Ahrweiler 1966, 438.

¹⁰⁹ Ahrweiler 1966, 438.

Lombard, Joannes Zonaras (a Byzantine chronicler from the 12th century), and Nikephoros Bryennios (a Byzantine historian from the 12th century).¹¹⁰

Another substantial contribution to the maritime history of Byzantium was made by the publication of *The Age of the ΔΡΟΜΩΝ: The Byzantine Navy ca 500-1204* by John Pryor and Elizabeth Jeffreys in 2006. In this work, the authors combine archaeological evidence with written sources. In the first chapter titled “Operational Context”, the authors discuss the emergence and history of the Byzantine navy, which includes references to the timber supplies especially regarding the rivalry with the Arab navy. This historical overview is derived mostly from Byzantine chronicles, such as that of Theophanes Confessor. The following chapters, which discuss the origin of the *dromōn* (a type of Byzantine warship), relies mostly on the written evidence, but also discusses the archaeological material. Especially in the discussion of the changes in shipbuilding practices, the authors refer to archaeological evidence, namely the Dramont E, Bozburun and Serçe Limanı shipwrecks.¹¹¹ In Pryor’s previous book *Geography, Technology, and War: Studies in the Maritime History of the Mediterranean, 649-1571*, different sources for Medieval ships were used, including both ship iconography and shipwrecks.¹¹² The written sources such as Byzantine military manuals including *Naval battles of Syrianos Magistros* (*Ναυμαχίαι Συριανοῦ Μαγίστρου*) and the naval warfare chapter from the *Taktika* of Emperor Leo VI the Wise (*Ναυμαχικά Λέοντος βασιλέως*) are also discussed in detail.¹¹³ These texts and other related material are also given in the appendices, which creates an important resource for the study of naval treatises of Byzantium. Although the work concentrates on shipbuilding and the navy, there is a lack of attention to the timber, for example, the appropriate species for warship construction, which can be traced from ancient authors and Late Antique military treatises, are not mentioned. Still, *The Age of the ΔΡΟΜΩΝ*, with Ahrweiler’s work create the backbone of Byzantine naval and maritime history. Pryor and Jeffreys, in the postscript of the book mention the discoveries of two longships at the Yenikapı excavations, which indeed proved to be more than two

¹¹⁰ Ahrweiler 1966, 438.

¹¹¹ Pryor and Jeffreys 2006, 146-48.

¹¹² Pryor 1992.

¹¹³ Dennis have edited and translated both, See Dennis 2008; 2010.

warships that contributed to the understanding of ancient warship building in the Mediterranean more than any previous archaeological evidence.¹¹⁴

A final work must be mentioned as it refers to the Arabic sources on shipbuilding timber. An account of the Muslim naval history was published by Aly Mohamed Fahmy in 1966 titled *Muslim Naval Organization in the Eastern Mediterranean, From the Seventh to the Tenth Centuries*. This work, which is again is a compilation of mostly Arabic primary sources incorporate different mediums of material which include also Greco-Roman sources such as the Aphrodito papyri. Fahmy argues that the Muslims did not produce accounts of their seafaring activities, the gaps in historians accounts are often filled by geographers and travelers' accounts.¹¹⁵ He suggests that the main sources for shipbuilding timber in Egypt are Abu Salih the Armenian (13th century), Ibn Mamati (1209) and Abd al-Latif al-Baghdadi (1232). Although he devotes a specific section to shipbuilding timber, he surveys the types of trees that were cultivated in Egypt from the primary sources, which were lebek, acacia (*Vachellia nilotica*), fig (*Ficus sycomorus*), palm (*Hyphaene thebaica*), and lotus (several *Nymphaea* species are endemic to Egypt).¹¹⁶

1.3.4 Conclusions about the Scholarship

This short overview has presented how the primary sources for timber in Byzantium –both written and material– have been discussed in the scholarship. Several shortcomings can be identified. In general, the publications which focus only on timber in the mainstream of Byzantine studies are very limited. This is partially due to the fact that the textual evidence regarding forest resources are scattered through a wide geographical and chronological range, and most scholars have specialized in more constrained regions, time periods, or sources of evidence. One example is Dunn's two works in comparison, his 1992 publication gives a more general overview of timber in Byzantium, and the latter publication focusing only to a region (Aegean) and a period (Late Byzantine and Frankish) and gives a more in-depth analysis from different and detailed sources. A second reason is that timber is used in different forms, from shipbuilding to icon

¹¹⁴ Pryor and Jeffreys 2006, 454.

¹¹⁵ Fahmy 1966, 9.

¹¹⁶ Fahmy 1966, 75-9.

production, its study requires specializations and technical information which may not be familiar to individual scholars. The discussion of these materials by non-specialists naturally have the risk of falling short of an in-depth analysis.

Lastly, although both the written and material evidence have been studied and published extensively, a limited number of works bring these two lines of inquiry together.¹¹⁷ In the past, the scholarship was limited to the analysis of the written material, which has led to broad generalizations, often intertwined with the general political and economic history of the empire and the current mainstream historiographical trends. The lack of archaeological material in previous studies can be explained by two reasons. Firstly, it might not have been available at the time of the publication. Most of the final reports of the Byzantine shipwrecks for example have been published in the 21st century. It generally requires years or even decades for shipwreck hulls to be properly excavated and documented, analyzed, and prepared for publication. The Serçe Limanı shipwreck, for example, was fully excavated between 1977-1979 and the first volume of its three-volume final report was published in 2004.¹¹⁸ For the eight Yenikapı shipwrecks that were excavated by the Istanbul Archaeological Museums and the Institute of Nautical Archaeology between 2005 and 2008, there have been three detailed reports for all the wrecks, while two of them have been published in more detail, all in the last five years.¹¹⁹ A similar situation is also present with the shipwreck on the Israel coasts, Tantura F for example was discovered in 1996, and although it was not entirely excavated, its final report was published after twenty years, in 2016.¹²⁰ Thus, although shipwrecks are discovered and recorded, it often takes a significant amount of time for them to be excavated, published and referred to in the wider scholarship.

Secondly, the scholars might not have the background or expertise to analyze the evidence which is often published as reports. For example, the cargo that are found in the shipwrecks have been discussed in the context of primary and secondary production, fluctuations of the volume of trade, or possible trade routes.¹²¹ These are often examined by the experts on the specific cargo items; Vroom, who is an expert in pottery for

¹¹⁷ Such as Dunn 1992 as discussed above.

¹¹⁸ Bass et al. 2004.

¹¹⁹ Pulak et al. 2015; Jones 2017, Ingram 2018, Özşait-Kocabaş 2018; Pulak 2018.

¹²⁰ Barkai and Kahanov 2016, 6.

¹²¹ Bass et al. 2009; McCormick 2012, 81-6; Russell 2013; Leidwanger 2017.

example, discusses Byzantine sea trade through the pottery finds in shipwreck cargos.¹²² Byzantine shipwrecks have been discussed with a focus on the ships themselves in the context of shipbuilding technology.¹²³ However, the study of the ship itself as an archaeological material has not been widely discussed in Byzantine studies. For example, in the entry called “Ships” in *The Economic History of Byzantium*, George Makris discusses the qualities of Byzantine ships, however only mentions Yassiada I briefly and relies heavily on written evidence.¹²⁴ Shipwrecks are instead discussed by Van Doorninck as a “Special Topic” in the volume, focusing not only to the technicalities of shipbuilding, but also the cargoes of selected Byzantine shipwrecks.¹²⁵ In Pryor’s contribution “Shipping and seafaring” however mentions various archaeological finds, such as the Yassiada I and II shipwrecks, the Bozburun shipwreck, and a preliminary comment on the shipwrecks from the Theodosian Harbor where the excavation was still continuing when the work was published.¹²⁶ Here it can be pointed out that Pryor has been working on maritime commerce and transport as well as Byzantine ships and shipbuilding, meanwhile Makris specializes in monasticism and relies on monastic documents for his overview. It is clear that scholars tend to utilize the material that they have an expertise on while discussing ships.

One last example is the chapter “Of Harbors and Trees: The Marmaray Contribution to a 2367-Year Oak- Tree-Ring Chronology from 97 Sites for the Aegean, East Mediterranean, and Black Seas” by Kuniholm et al, which is a crucial publication regarding the timber exchange during the Byzantine period, not only for it is a detailed database for the oak tree ring chronology, but also for the discussion of possible timber trade routes.¹²⁷ Reports on dendrochronological analysis such as Kuniholm et al. or reports on pollen analysis have been produced by specialists and the analysts themselves, and might be overlooked by historians, or are recently being published thus they have not been integrated into the literature yet.

¹²² Vroom 2016.

¹²³ Kahanov 2011; Pomey et al. 2012; Pulak 2018.

¹²⁴ Makris 2002, 97-8. This entry is from *The Economic History of Byzantium from the Seventh through the Fifteenth Century*.

¹²⁵ Van Doorninck 2002a, 899-905.

¹²⁶ Pryor 2008, 484-85. This entry is from the *Oxford Handbook of Byzantine Studies*.

¹²⁷ Kuniholm et al. 2015.

However, although the mainstream scholarship has prioritized written material in the past, the material evidence, which have been present in reports and archaeological publications for in fact a long period of time, is now being integrated into broader perspectives. This is crucial as the material evidence shows details about micro-regional differences and connectivities that may be absent in the written primary sources. Timber is a raw material that –as demonstrated– can be found in various primary sources, and should be studied in an interdisciplinary approach, through which not only written evidence or material evidence is considered, but both are integrated into a broader perspective of raw material movement in the Empire and the broader Mediterranean.

1.4 *Aim*

The aim of this thesis is to re-examine textual and material sources for exploitation and supply of timber for shipbuilding between 4th and 11th centuries in the Eastern Mediterranean, with a particular focus on new research and material evidence, particularly shipwrecks. The specific type of timber that is used in a part of a ship depends on many micro- and macro-level considerations. It depends, for example, on technical considerations. Different timber qualities are required for different parts of ships; while the keels are to be made of very durable materials, the masts would have to be from very tall, intact trees. Then, the type of ship would have to be considered, Mediterranean war galleys were typically made from softwoods such as pine wood, meanwhile hardwoods such as oak could be utilized in merchant ships without a problem. The choice of the tree is also related with the construction methods of the ship: while the hull planks tend to be more uniform in species, depending on the ship, more variety can be seen in framing timbers.

In a broader perspective however, availability and accessibility of timber plays an important role in shipbuilding. Local wood could be cheaper to use, however, due to the topography of the region, it could also be logistically challenging or impossible to acquire. In this case, imported wood which could be acquired more easily in fact could cost less for the shipwrights. The local forests might also in time be cleared for agricultural purposes. At a time when frontiers and borders were rapidly shifting, forested regions could change hands, affecting the local populations' exploitation of the resources. Forested areas were often protected by the state, as timber was not only a valuable trade

commodity but was also a strategic war material that the states would rather prevent from being supplied to foreign powers.

The timber supply for shipbuilding in Byzantium was thus the result of a complex interplay between numerous factors. Therefore, this thesis aims to draw a broad picture of timber in Byzantium from a nautical perspective. It is concerned with the regulation of its exploitation and supply, which may help to explain the long-term relationship between timber supply for shipbuilding and technology and the economy, the environment and resource exploitation, and the political and strategic situation of the Byzantine Empire.

As Dunn suggests, the study of the supply and exploitation of timber in Byzantium requires scholars to adopt a “long-term” perspective due to the fragmentary evidence.¹²⁸ The scope of this research will be diachronic, and limited by the shipwreck evidence at hand, roughly from the 4th to the 11th century CE (from Yassiada II shipwreck, c. 375-425 CE to Serçe Limanı shipwreck, c. 1025). This period includes various changes in the empire’s frontiers with expansions and contractions, as the Eastern Mediterranean was not only as the main trading hub of Byzantium, but also included forested regions suitable for shipbuilding. Considering that the demand for shipbuilding timber increased with the Byzantine-Arab naval rivalry in the region, it is suitable to determine the geographical scope of the research as the Eastern Mediterranean. Meanwhile, sources before 4th century and after 11th century as well as from outside the Eastern Mediterranean illuminate different aspects of timber use and can be related to the period and region of study. Thus, these sources are also included in the scope of this thesis.

1.5 Methodology

As illustrated, there are several different types of sources to understand the timber exploitation and supply for shipbuilding in Byzantium. However, little work has been done to combine these, especially the literary sources with the archaeological evidence.¹²⁹ It is therefore essential to adopt an interdisciplinary approach and incorporate these various types of information in a thematic and chronological manner to understand how

¹²⁸ Dunn 1992, 239.

¹²⁹ See Canavas 2007 for a similar comment on of timber exploitation in Sicily.

the evidence of timber supply and exploitation can contribute to our knowledge of Byzantine history and archaeology.

In this regard, the two main primary sources, both written and archaeological material will be analyzed in the context of shipbuilding. The literary sources will be sorted by region, and analyzed in relation to the political, economic, and environmental conditions of the period. The wood types from the shipwrecks will be analyzed in accordance with their role in the ship construction, parts of the ship's hull, period, and location. The comparison of these traits can draw the picture of local, regional, or long distance trade of timber in Byzantium.¹³⁰ The environmental data then will be compared to the general discussion outlined by the previous material. As the conclusion, I hope to illustrate the long-term relation between timber supply for shipbuilding with technology and the economy, the environment and resource exploitation, and political and strategic situation of the Byzantine Empire.

¹³⁰ These terms do not have established meanings in the literature. In the scope of this thesis on the other hand, local trade will be taken as short-distance trade often conducted with vessels shorter than 10m in length. Regions are very often created through the topographical limitations. While the extent of regional trade is between the local and long distance interactions, it also depends on the particular good that is being exchanged along these routes. Lastly, long distance trade, by distance exceeds regional trade.

Chapter 2:

EVALUATING TREES AND EASTERN MEDITERRANEAN FORESTS FROM MATERIAL EVIDENCE AND ANCIENT – MEDIEVAL WRITTEN SOURCES

Timber that is needed for shipbuilding during the Byzantine period could be supplied either locally or from long distances. To understand the supply systems, the forest coverage and the interaction between humans and the forests should be examined. There are different types of evidence which reveal about the ancient forest coverage as well as how the people have exploited this raw material. In this chapter, both written and material evidence will be discussed to draw a general picture of the interaction between the people and the forests in the Byzantine period. In order to do this, first, proxy evidence will be evaluated to analyze to what extent the environment determined the forest coverage, and how the forest coverage might have changed through the period under scrutiny. In this regard, there are also several written sources of ancient authors which illuminate the wooded regions of the empire. Only after looking at this evidence for a broad understanding of the ancient forest coverage, the relationship between men and forest can be discussed. This involves the types of forest exploitation as well as deforestation. This is followed by investigating how the ancient and medieval sources mention shipbuilding timber, the preferences, logistics and prices. The supply of this material is therefore evaluated in a nautical perspective, narrowing the discussion specifically to shipbuilding timber.

2.1 Proxy Data for Forest Coverage and Timber Supply

It is not possible to fully recreate ancient forest coverage; however, certain indicators can give an idea about the forest regimes. Veal proposes that the base determinants for the growth of different plant types is geology, topography, climate, and soils.¹³¹ This section will be focusing on especially pollen data and also climate to outline the forest coverage during the Byzantine period in the Eastern Mediterranean.

¹³¹ Veal 2019, 13.

To start with, it can be observed that in the Eastern Mediterranean proliferation of wooded areas is related to the settlement patterns. Touwaide argues that plant coverage and population have a negative correlation, so the forest cover decreased in periods of demographic expansion and increased during demographic reduction.¹³² The reason behind this is not only the exploitation of forest resources but also the land clearance needed for agricultural activities; cultivated land expanded as the population increased and reduced as the population declined. Therefore, intense agricultural activities point to decreased forest coverage. A material evidence for this is the AP:NAP ratio. AP (arboreal pollen) can be compared to the amount of pollen from other plants (nonarboreal pollen), and this ratio can give a general impression of whether the landscape was wooded or not.¹³³ A rise in AP can be inferred as an increase in forest coverage, due to either decrease in agricultural activities and land abandonment, or the consequence of wetter climatic conditions.¹³⁴ The Nar Lake data, for example –which is very close to Cappadocia– show a high correlation between the historical events which had led to depopulation and decrease in agricultural activities such as the Arab advancements into Anatolia.¹³⁵ During the period of abandonment, from early 8th to mid-10th centuries, there is a striking increase in arboreal pollens.¹³⁶

This change is also visible from the termination of the Beyşehir Occupation Phase (BOP), which was a period of increased human activity (1450 BCE – 600/700 CE) that could be identified from the pollen diagrams from southwest Turkey.¹³⁷ BOP however was not just a local phenomenon, Roberts argues that this pattern is also visible in the pollen records from central and northern Anatolia, Cyprus, and the southern Levant.¹³⁸ Late Antiquity therefore was marked by a large-scale intensification of the rural settlement in several regions of the Mediterranean, in particular in its eastern part, including Anatolia and the Levant.¹³⁹ This period saw the intensification of agricultural

¹³² Touwaide 2020, 322.

¹³³ Darvill 2008, 36 AP:NAP ratio.

¹³⁴ England et al. 2008, 1240.

¹³⁵ England et al. 2008, 1240-243.

¹³⁶ England et al. 2008, 1239.

¹³⁷ Eastwood et al. 1998, 70. The name was given as such due to the clear expression of this period from the Beyşehir pollen record.

¹³⁸ Roberts 2018, 53.

¹³⁹ Izdebski et al. 2015, 3.

activities, crop cultivation and arboriculture accompanied with forest clearance.¹⁴⁰ It is important here to emphasize the practice of arboriculture, –which is the anthropogenic cultivation of trees, vines and shrubs– is often indicated by the cultivation of olive (*Olea*) and walnut trees (*Juglans*) and Chestnut (*Castanea*). Both walnut (*Juglans*) and chestnut (*Castanea*) were used as shipbuilding timber and are attested both as repair pieces and hull planking of shipwrecks dating to Byzantine period from Eastern Mediterranean (see Chapter 4). It is possible that some of this might be from cultivated trees, and not wild trees. However, these trees are cultivated for their nuts, thus it is not dominant in shipbuilding.

Around the 7th century, however, this organized and well-managed landscape had gone into decline and pine forest was recolonizing abandoned agricultural land.¹⁴¹ This was “a sequence of progressive expansion of nonanthropogenic vegetation”, which is the indication of post-arable growth, with woodland re-growth.¹⁴² This phase is marked by a sharp increase in AP, thus the expansion of woodland, with pine being the dominant tree type, and it can be inferred that the abandoned landscapes ended up as pine scrublands and forests in the eighth century.¹⁴³ Nar Lake is again an example of this, where expansion of pine forests across the Taurus and Pontic mountain chains is visible (Figure 1).¹⁴⁴ As also attested in the written sources, these two mountain chains are the most probable suppliers of shipbuilding timber during the Byzantine Period.

CLIMATE	RURAL LAND USE AND POPULATION		
950–1400 C.E.	moderately wet	950–1400 C.E.	population increase, agro-pastoral economy
750–950 C.E.	moderately dry	680–950 C.E.	rural abandonment, greatly reduced farming, forest recovery
540–750 C.E.	very wet	pre-680 C.E.	dense settlement, agriculture of cereals and tree crops
270–540 C.E.	dry		

Figure 1 Summary Interpretation of High-Resolution Pollen and Stable Isotope Data, Nar Lake, 270–1400 C.E. (Haldon et al. 2014, 142.)

¹⁴⁰ Eastwood et al. 1998, 70.

¹⁴¹ Eastwood et al. 1998, 82.

¹⁴² Haldon et al. 2014, 139.

¹⁴³ Eastwood et al. 1998, 70; Izdebski 2013, 150.

¹⁴⁴ Haldon et al. 2014, 144.

It is shown from the pollen evidence from Sagalassos for example, coniferous forests (evident from the *Pinus nigra*, *Abies cilicica* and *Cedrus libani* pollens) were present on the slopes above Sagalassos in the early Byzantine period. Although the city required large amounts of wood from these sources for the intensive industrial activities, the forests above the city made up of coniferous trees as well as patches of deciduous oak (*Quercus cerris*) below the city were preserved at least up to the early Byzantine period.¹⁴⁵ Vermoere et al. argue that the occupants of Sagalassos were very much aware of the environmental significance of the needle-leaved forests on the slopes above the city.¹⁴⁶ This shows the deliberate forest management during this period.

Scholarship have argued that the regression of cultivated land and an advance of forests might have been related to population decrease after Late Antiquity, did not occur simultaneously in the region.¹⁴⁷ This can for example be documented on the island of Lesbos, where several basilicas that are situated inside forests, which he argues points to the new advancement of forest.¹⁴⁸ He argues that the afforestation of the region around Limyra started in the 7th century.¹⁴⁹ Izdebski argues that these changes, such as the decline in agriculture happened later in Northern Anatolia, with the movement of Turkic nomad groups in 11th century.¹⁵⁰ Therefore, a general increase in the wood supply can be assumed for the Eastern Mediterranean, but occurring at different times in different regions.

In addition to the anthropogenic effect on wooded regions, climate also plays an important role in determining the forest coverage. Some trees could indeed be highly sensitive to climate. Almost all trees would be affected by climatic changes, and it would alter their habitats and move them to lower or higher altitudes. When the regions where a tree grows change, the possibilities of its exploitation also change. For example, if a tree species ceases to appear in lower altitudes, it might be used due to the logistical problems that higher altitudes create. Olive (*Olea europea*) for example demonstrates a similar phenomenon with archaeological evidence. Olive was cultivated in Sinop

¹⁴⁵ Vermoere et al. 2003, 170.

¹⁴⁶ Vermoere et al. 2003, 171.

¹⁴⁷ Koder 1994, 157.

¹⁴⁸ Koder 1994, 162.

¹⁴⁹ Koder 1994, 163.

¹⁵⁰ Izdebski 2012, 63.

extensively until the 7th century, however in 7th century, the climate changed to more cool/wet condition in the region.¹⁵¹ Since olive is more suitable for a dry climate with spring rainfall, this climatic change made the olive production industry in the area collapse.¹⁵² It has therefore been argued that the olive cultivation in the upland regions of Anatolia was severely affected and reduced due to the climate cooling in the 1st millennium CE, evident from the decrease olive oil production.¹⁵³ Another tree type which was potentially affected is the Turkish Pine (*Pinus brutia*). It occurs today below 1400m above sea level, which is the lower parts of the mountains. However, its range might have been extended much higher especially during the warm climatic phases such as the Medieval Climate Anomaly (850 – 1300 CE).¹⁵⁴ Turkish pine (*Pinus brutia*) is very common in shipbuilding, and this evidence suggests that it might have been more prevalent during warm periods, like between 9th – 12th centuries CE.

Overall, the emphasis on the pine proliferation might be related to the fact that there are various *Pinus* species endemic to the region that grow on both lowland and mountains, therefore is dispersed to a wide area.¹⁵⁵ Grove and Rackham also mention the resilience of Mediterranean vegetation, they propose that abandoned farmland would turn into steppe in a year, and garrigue (scrubland) in five.¹⁵⁶ They emphasize that especially pine, cypress and deciduous oaks invade both *maquis* and ex-farmland by seed.¹⁵⁷ Therefore, since pine, cypress and deciduous oak are more prone to grow up on abandoned farmland, this could point to an increase of them after 7th century. These are species that show up very frequently on shipwrecks, and their resistance and fast invasion of ex-farmland might be one of the reasons why they were preferred in shipbuilding. Also, there could have been changes in the forest coverage due to climate change on species level, depending on how wetter/drier or warmer/cooler conditions have affected the specific tree species. However this is very species specific and each tree type should be evaluated based on the climatic conditions of the tree itself, and the reconstructed ancient climate.

¹⁵¹ Haldon et al. 2014, 146

¹⁵² Xoplaki et al. 2015, 62.

¹⁵³ Roberts 2018, 56-9.

¹⁵⁴ Bakker et al. 81.

¹⁵⁵ Grove and Rackham 2001, 51.

¹⁵⁶ Grove and Rackham 2001, 60.

¹⁵⁷ Grove and Rackham 2001, 60.

2.2 *Distribution of Forests in the Ancient Sources*

The pollen data does give both a holistic and region specific changes in wood coverage, and reconstructions of ancient climate might give clues about the distribution of a certain species, however this should also be supported by written evidence referring to wooded regions in antiquity. Several ancient authors and later travelers accounts refer to the flora of the Eastern Mediterranean and shipbuilding activities. Ahrweiler's argument has already been noted in which she asserts that Byzantium has never lacked technical staff and material resources required for shipbuilding: it could easily find them in all coastal regions of its territory.¹⁵⁸ However, certain regions stand out in the sources, the Black Sea coast including Bithynia, Constantinople and Thrace, the Aegean, the coasts of southern Asia Minor, Cyprus, and the Levant. Understanding the forest coverage of these regions and their connections should reveal a great deal about the system of timber supply for shipbuilding.

2.2.1 *Black Sea Coasts of Asia Minor*

The Black Sea coast of Asia Minor is still a heavily forested region. The ancient sources also mention this region not only for having superior timber sources, but also the convenience of transporting them.¹⁵⁹ Theophrastus, who was writing in the 4th century BCE, discusses the regions that provide good-quality timber to Greece, and although he does not name any species, he emphasizes especially Macedonia, Pontus, and Rhyndakos (Bursa, Bithynia) as suppliers (Theopr. *Hist. pl.* V.ii.1). Xenophon around the same period mentions the port of Calpe in Bithynia, in the middle of the route from Heraclia (modern day Ereğli) to Byzantium, where you can find "large amount of fine ship-timber, on the very shore of the sea" (Xen. *An.* VI.iv.4). Pliny later includes Bithynia, Pontus, and Macedonia as having high quality firs (Plin. *HN.* XVI. Lxxvi. 197-199). Strabo relates that Sinop and the mountainous region extending as far as Bithynia have shipbuilding timber that is excellent and easy to transport (Strabo XII, 3.12). He follows a similar account for Colchis, on the eastern part of the Black Sea coast of Asia Minor (modern day Georgia) "for it not only produces quantities of timber but also brings it down on

¹⁵⁸ Ahrweiler 1966, 438.

¹⁵⁹ For a general analysis of the Black Sea region as a provider of timber during the Classical period see Hannestad 2007, 85-99.

ivers” (Strabo XII.ii.17). It is evident that he paid attention not only to the abundance of the forests but also to the logistics of transporting the timber to the harbors.

Another account for the abundance of wood in the Black Sea coast is from al Idrisi’s (1099-1165 CE) geographical writings, which derives from earlier sources. The town of Lanio (modern day Ünye), about 250 km to the east of Sinop, is described as a place where ships and warships were built.¹⁶⁰ A later source from the 13th century, the Arab geographer Ibn Said, who, in describing the coastal navigation routes of the Black Sea, mentions that “Between it (Amasya) and Sinop is six days, and the road is through the mountains of pine (*jibal al-snawbar*) full of wood and water, and cut wood for construction is floated down for the arsenal (*dar al-sina’a*) of Sinop.”¹⁶¹ Pierre Gilles, writing in the mid-16th century, confirms the earlier accounts, stating that from Propontis to Colchis (modern day Georgia) there were “inexhaustible forests” and therefore concludes that the Byzantine Empire not only could supply itself and its neighbors with timber for buildings and ships, but also could send it to Egypt, the Red Sea and Africa. He concludes that, referring to Constantinople, “this big city would never lack wood”.¹⁶² French travelers Perrot and Guillaume in mid-19th century while describing the region of Prusias ad Hypium in western Black Sea coast of Asia Minor (modern day Düzce) call it the “Sea of Trees”.¹⁶³

2.2.2 Constantinople and Thrace

Another center for shipbuilding that was supplied with timber was Constantinople, where not only merchant ships were built, but also state sponsored galley building for the navy took place. Large stands of trees suitable for constructing ships and buildings in the region of Constantinople were cited in an anonymous encomium to the emperors Manuel II and John VIII.¹⁶⁴ Meanwhile, timber is a strategic material in military conflict as it is used for naval ship construction, and the arsenals were not always built in the areas convenient for timber to be shipped to due to political conflict. Matschke proposes that

¹⁶⁰ Jaubert 1832, 3:70-7.

¹⁶¹ Redford 2014, 91.

¹⁶² Gilles 2007, 268.

¹⁶³ Perrot and Guillaume 1862, 20.

¹⁶⁴ Isidore of Kiev, *Panegyrikos to Manuel II and John VIII*, ed. Lampros, III, 186, cited in Matschke 2001, 327.

the surroundings of Constantinople had enough timber for construction works during the Late Byzantine period, but as the city was increasingly cut from the hinterland, its access to these sources became difficult, if not -in his words- “impossible.”¹⁶⁵ In Constantinople for example, Günsenin proposes that the harbor of Kosmidion (modern day Eyüp) was where the Byzantine fleet would have been constructed until the 14th century, pointing out that the location was especially some distance from the Italian colonies.¹⁶⁶ She suggests that it is not possible to determine when the Kosmidion arsenal was constructed, although it was abandoned during the reign of emperor Michel VIII Palaiologos (r. 1259–1282), but resumed operation under Kantakouzenos in relation to the Genoese blockade of the Bosphorus during the Byzantine - Genoese War of 1348–49.¹⁶⁷ The Genoese had the control over the sea routes from which necessary timber could have been brought to the Kosmidion arsenal situated at the end of the Golden Horn. Thus, the timber needed for naval construction that in normal conditions could have been imported by sea from the regions around Constantinople, such as the Black Sea coast or Bithynia, was instead brought by oxen from the Strandza Mountains of Thrace (Kantak. IV.11, 5-15). This blockade, which is described by historian Nicephorus Gregoras (c.1295 – 1360), gives an example of how Constantinople was supplied with timber for shipbuilding.¹⁶⁸

During the construction of this fleet, Nicephorus Gregoras also states that “the architects and leaders of the fleet” set upon the city's inhabitants in their search for planks of wood and tow to repair and caulk the hulls, dismantling houses to use the wood for building ships, which is definitely not ideal but was an emergency measure (Greg. XVII.6). Since it was recorded that timber was carried by oxen and mules from nearby mountains, the need for timber which lead to the destruction of houses in the city might be an indication that overland transport was useful only to a certain extent, or that it was

¹⁶⁵ Matschke 2001, 328.

¹⁶⁶ Günsenin 2017, 416.

¹⁶⁷ Günsenin 2017, 416.

¹⁶⁸ The backdrop of the Byzantine – Genoese War of 1348–49 was the increasing Genoese control over the food supply and trade of Constantinople: they could cut off the grain supply from the Black Sea (Nicol 1993, 220). Conflict arose in the August of 1348, and both sides started attacking from the two sides of the Golden Horn, burning merchant ships and grain houses on both sides. Emperor John VI Kantakouzenos (r.1341-1354) who returned to the capital in October 1348 ordered for a navy to be built and Nicephorus Gregoras records that although many residents of Constantinople contributed willingly, the tax gatherers, namely a special commissioner called Constantine Tarchaniotes collected the rest of the money “with a very bad grace” (Greg. XVII.4).

not possible when more timber was needed. Lastly, since timber is very heavy and logistically problematic to transport, political conflicts over territories were especially troublesome for the Byzantines concerning timber supply.

2.2.3 *The Aegean*

The Aegean islands are not known in particular for being densely forested; Diodorus Siculus for example mentions the shipyards in the island of Rhodes making ships from imported timber, presumably from one of the previous sources he mentions (Diod. Sic. XIX.lviii.4). However, various sources mention forested regions in the northern coasts of the Aegean, especially Macedonia. Theophrastus, for example, relates that the best timber that was coming to Greece for building activities was from Macedonia (Theop. *Hist. pl.* V.ii.1). Various scholars have also pointed this out, discussing the political leverage that Macedonia had over Athens in the Classical period due to its vast resources of shipbuilding timber.¹⁶⁹ Borza also emphasizes that all major Macedonian rivers, the Haliacmon, the Strymon, the Loudias, and the Axios, were suitable year-round for the flotation of timber, which made it easier logistically for the timber to be exported by the sea.¹⁷⁰ There are few sources from the Byzantine period discussing the Macedonian forest resources; however, John Kaminiates, who allegedly penned an account of the siege and sack of Thessaloniki in 904, mentions the “huge shady trees” in the environs of the city (Kam. 5.36). Various accounts of timber exploitation by the monks of Athos, such as for firewood both for their own use and to export for profit can also be included.¹⁷¹ Travelers accounts from much later periods still mention the “richly wooded” areas of Northern Aegean and state that the timber would be carried to Salonica to be exported.¹⁷² Holland mentions pine, oak, chestnut and beech trees in his account of travel in the Aegean in the early 19th century.¹⁷³

The coasts of the Aegean were wooded only in parts, but the transportation of timber by the sea could allow shipbuilding along the coasts and also the islands. In the 10th-century *De Cerimoniis Aulae Byzantinae*, for example, ships crews were left in maritime

¹⁶⁹ See Borza 1987, 32-52 and more recently Karathanasis 2019, 707-26.

¹⁷⁰ Borza 1987, 38.

¹⁷¹ Thomas et al. 2000, 240, 287.

¹⁷² Holland 1815, 298.

¹⁷³ Holland 1815, 302, 305.

themes to fell timber at the theme of *Kibyrrhaiotai* which included the coasts of Caria, Lycia, Pamphylia and parts of Isauria, as well as the theme of the Aegean Sea, which included most the islands such as Lesbos and Chios (*De Cer.* II.45. R664-65). This shows that these regions were suppliers of timber, especially for shipbuilding, although they are not mentioned frequently in the written sources.¹⁷⁴ Makris argues that late Byzantine period evidence suggests the existence of shipbuilding centers in Smyrna, Lemnos, Rhodes, Ainos, Patmos and Monemvasia.¹⁷⁵ Strabo, for example, mentions a region called Cyparissus near Monemvasia, probably after the cypress tree growing in the region (Strabo, IX. iii, 13). Kalligas argues this was Mount Parnon, which also supplied the Byzantine shipbuilding activities in the region.¹⁷⁶ In general, the Aegean (except for northern Aegean) is not described as heavily forested in the literary sources; however is known to have various shipbuilding centers, attesting to a constant movement of timber.

2.2.4 Coasts of Southern Asia Minor

A very prominent resource for timber for shipbuilding, which also became a major battleground for the Byzantines and the Arab fleet due to this very reason was the coasts of southern Asia Minor. The use of the timber from this region is attested in many ancient and medieval sources. One of them is again Strabo, who writes that Hamaxia, a hilltop settlement that is about 6 km northwest of modern day Alanya in Rough Cilicia, had a harbor to which shipbuilding timber– which was mostly cedar– would be brought down from the mountains. Strabo claims that this region was much more abundant in cedar-wood for ship building than any other (Strabo, XV, 5-3). Mitford states that in the 2nd century BCE, mercenaries and shipbuilding timber were Rough Cilicia’s only exportable commodities.¹⁷⁷ Antony gifted this region to Cleopatra since it was suited to the building of her fleets (Strabo XIV. 5,3). Rough Cilicia in general is described by Strabo as being suitable for piracy as it did not only have “harbors and fortresses and secret recesses” but also had extensive forests with shipbuilding timber (Strabo XIV. 5-6). Similar sentiments can be traced in Roman poet Lucan’s *Pharsalia*, where he narrates the civil war between Julius Caesar and Pompey the Great. After Pompey’s campaigns against the Cilician

¹⁷⁴ This reference is discussed in detail in Section 3.1 State Ownership of the Woodland of this thesis.

¹⁷⁵ Makris 2002, 98.

¹⁷⁶ Kalligas 1990, 54.

¹⁷⁷ Mitford 1980, 1234.

pirates, Lucan writes, “*Mallos et extremae resonant navalibus Aegae/itque Cilix instat, iam non pirate, carina.*” Mallos [close to modern day Adana] and the distant Aegean resonate with the noise of the shipyards, and the Cilician, no longer a pirate, sails in proper vessels” (Luc. III, 227-228).

A hagiographical account from Lycia also illustrates the influence of these wooded areas in the region on the peoples. Saint Nicholas of Sion, was an abbot of the Monastery of Holy Sion near Myra in the early 6th century and was ordained as the bishop of Pınara in Lycia.¹⁷⁸ In his hagiographic account, written shortly after his death, a miracle related to use of timber in church construction is mentioned. A villager from Plakoma (close to modern day Çağman, Demre) told the saint that a sacred tree was disturbed by an unclean idol (15).¹⁷⁹ It is later revealed that a man tried to fell the tree and was slaughtered by it (16). After Saint Nicholas prayed to God, the spirit was repelled, and the tree felled. It was recorded to be a cypress tree, three-and-a-half cubits thick and forty cubits tall (around 1.64 meters wide and 18.80 meters tall), which was considered by the locals to be a very unusual size.¹⁸⁰ The tree was taken to his church and, as Morrisson suggests, was probably used as a roof beam.¹⁸¹

2.2.5 Cyprus

Cyprus was also cited by earlier geographers and historians as being rich in forests suitable for shipbuilding. Theophrastus mentions that in Cyprus, kings would not cut trees, to let them grow to greater lengths and sizes, and that the transport of the timber was difficult. (Theopr. *Hist. pl.* V.viii.1). Bekker-Nielsen proposes that this problem with the transportation was because the island’s timber resources were concentrated in the highland areas, and the lack of appropriate road networks leading to the higher portions of the mountains where river transport was not possible.¹⁸² Strabo describes the forests of Cyprus as having become degraded by the late 1st century BCE. He mentions the ancient author Eratosthenes’, statement that the island had thick forests; however, the mining

¹⁷⁸ Ševčenko and Ševčenko 1984, 11.

¹⁷⁹ Foss 1991, 332-33.

¹⁸⁰ Ševčenko and Ševčenko 1984, 135 notes that this cubit should not be confused with the land measuring cubit but must be taken as “woodsawing” cubit, see Schilbach 1970, 20-1.

¹⁸¹ Morrisson 2016, 110.

¹⁸² Bekker-Nielsen 2013, 15.

industry's need for firewood and the building activities in the shipyards have depleted these resources (Strabo XIV. 6,5). This industrial activity is attested widely in the archaeological record. Kassianidou estimates that over 4 million tons of copper smelting slag was produced in the antiquity.¹⁸³ She argues that the copper industry would have played a significant role in the gradual depletion of the forests in the island.¹⁸⁴ Strabo, on the other hand, explains that the exploitation did not prevail over the growth, and therefore anyone who wished, or was able, to cut out the timber and to keep the land thus cleared as his own property and be exempt from taxes (Strabo XIV. 6.5). This might be an indication that timber was always needed; however, the manpower to fell it might have been short and that the central authority might have wanted to clear land for agricultural activities. Therefore, people were encouraged to clear land of timber, in return for owning that land and certain tax privileges, for the central authority to promote settlement or development. Ammianus Marcellinus, who was writing in 4th century CE, famously related that Cyprus was so fertile in forest resources that with only local resources it could build cargo ships from the very keel to the topmast sails and equip them completely (Amm. Marc. XIV.8,14). The island was almost certainly a source of timber for Byzantium and the Islamic caliphate as long as the timber was able to be transported to the shore. In early 9th century, fifty cedar trunks were sent to the patriarchate of Jerusalem Thomas (807- 821) for repairs to the Holy Sepulchre.¹⁸⁵

2.2.6 *The Levant*

The last region that should be mentioned in the eastern Mediterranean is the Levantine coast. The forests of this region are prominent in the earlier sources, going back as far as the Bronze Age. It is often mentioned in the context of timber exports to Egypt; due to its lack of timber, Egypt had to maintain diplomatic and trade relations with Syria, Lebanon and Cyprus the Near Eastern civilizations.¹⁸⁶ The façade of Naqada IIC/D cultic building made of cedar logs and a cedar box from the Naqada IIC/D Abydos tomb U-127 from the 4th millennium BCE has been dubbed the earliest large objects made of cedar

¹⁸³ Kassianidou 2013, 37.

¹⁸⁴ Kassianidou 2013, 43.

¹⁸⁵ Papacostas 1999, 53.

¹⁸⁶ Broodbank 2013, 287-88.

(and thus imported) known in Egypt.¹⁸⁷ One of the earliest examples of such evidence is the Palermo Stone, which are the annals of the Kingdom of Egypt, possibly dating to between 2500 and 2350 BCE. In the section of the reign of Snefru, there is a direct evidence to the importing of timber for shipbuilding from Byblos (PS r.VI.2).¹⁸⁸ In the Amarna Letters, 14th-century BCE clay tablets recording the correspondence between the Egyptian administration and surrounding states, between 14th century BC, several references to this exchange of timber is made. In tablet EA 35 for instance, King of Alashiya (modern Cyprus) mentions the lumber that he has sent to Egypt and requests payment (EA 35, 27-29).¹⁸⁹ Both Theophrastus and Pliny refer to the region for having high quality cedar trees (Theophr. *Hist. pl.* V.viii.2; Plin. *HN.* XVI. Lxxvi. 197-199). Especially the cedar from Lebanon is traced in various sources from the epic of Gilgamesh (written c. 2150 – 1400 BCE) to the construction of Solomon's temple.¹⁹⁰ Diodorus Siculus, who wrote in the 1st century BCE about the conflicts around the Eastern Mediterranean after the death of Alexander, refers to the trees of the region in the context of shipbuilding. Antigonus I Monophthalmus, when building his fleet "carried wood to the sea from Lebanon" (Diod. Sic. XIX.lviii.2). He continues to describe the forest coverage of the region "This mountain range extends along the territory of Tripolis, Byblos, and Sidon, and is covered with cedar and cypress trees of wonderful beauty and size" (Diod. Sic. XIX.lviii.3). Again, the emphasis is on the cedar sources, in addition to cypress. Then, he mentions the establishment of five shipyards, at Tripolis, Byblos, and Sidon, where the timber was coming from the aforementioned forests and also Cilicia, that was being supplied by Taurus Mountains. As previously mentioned, the shipyard at Rhodes on the other hand again, made ships from imported timber (presumably from one of the previous sources he mentioned) (Diod. Sic. XIX.lviii.4). However, this region was already lost to the Arabs in the 7th century, thus the Byzantine exploitation of the timber sources was short-lived. One of the latest references to timber use from this region that should be mentioned is for the construction of the basilica dedicated to the Mother of God (the site is yet to be identified) in Jerusalem by Emperor Justinian (r. 527- 565), related in *De aedificiis* by Procopius. Since the basilica had a very wide nave, it was not easy to

¹⁸⁷ Sowada 2009, 26.

¹⁸⁸ Wilkinson 2000, 141.

¹⁸⁹ Rainey 2015, 340-43.

¹⁹⁰ See Meiggs 1982; 49-87, 'Cedars of Lebanon'.

find suitable timber suitable for supporting the roof. Thus, they searched for longer pieces of timber and found “a certain dense forest which produced cedars of extraordinary height” (Procop. *Aed.* V.vi.14-15).

An earlier example can be mentioned from the Roman period, more specifically, the reign of Hadrian (r. 117-138 CE).¹⁹¹ More than one hundred inscriptions were found in the forests of Lebanon, the most common one being:

Imp(eratoris) Had(riani) Aug(usti) d(e) f(inito) s(ilvarum) a(rborum) g(enera)
IV c(etera) p(rivata).

*Boundary of the forests of the emperor Hadrian Augustus: Four species of trees reserved under the imperial privilege.*¹⁹²

Only four tree species were reserved to the emperor and the rest could be felled by anyone who wished to do so. Meiggs lists four species he thinks might have been included in the restricted ones: cedar, cypress, juniper, fir, pine, and oak.¹⁹³

Cedar and cypress can easily be distinguished from earlier sources as well, from the archaeological record, vessels from Egypt dating to 3rd and 2nd millennium BCE and the Uluburun shipwreck from Late Bronze Age (late 14th century BCE) was made from cedar.¹⁹⁴ Late Roman and Byzantine era shipwrecks from the region, Dor 2001/1 and Dor 2006, however, both have cypress planking.¹⁹⁵ Pine is also attested in shipbuilding in the region in both earlier and later periods of Hadrian’s reign. The Kyrenia shipwreck (4th century BCE) that was found off the coast of Cyprus as well as Ma’agan Mikhael shipwreck (5th century BCE) from the coast of Israel had their hull built mostly with pine.¹⁹⁶ The use of pine as the hull planking is very common and also attested in various shipwrecks such as Tantura B dating to 9th century CE from the Israeli coast.¹⁹⁷ Fir,

¹⁹¹ Abdul-Nour 2001, 64-80.

¹⁹² Hughes 2005, 41; IGLS 5001, IGLS 5124.

¹⁹³ Meiggs 1982, 86.

¹⁹⁴ Liphschitz and Pulak 2007/2008, 76; For the Gawasis evidence see Ward 2012; for Dashur boats from Middle Kingdom see Creasman 2010, 113.

¹⁹⁵ Liphschitz and Pulak 2007/2008, 76; Liphschitz 2012a, 4, 7-8.

¹⁹⁶ Liphschitz 2009, 21.

¹⁹⁷ Wachsmann et al. 1997, 7; Pomey et al. 2012, 271.

although not as widespread in the archaeological record as the previously mentioned tree types, has also been found as hull planking, at the coast of Israel in the shipwreck Ma'aghan Mikhael B dating to 7th-8th centuries CE.¹⁹⁸ Meiggs eliminates juniper as he believes that it would not be used as shipbuilding timber.¹⁹⁹ It is true that juniper has not been found as a common tree type in the shipwrecks recovered from the Eastern Mediterranean. Mikesell proposes that the specified tree types in the inscriptions must be cedar, fir and pine, and either cypress or juniper.²⁰⁰ However, he argues that the locations of the inscriptions correspond to the modern distributions of the conifers in the region, except for juniper, thus the trees must have been cedar, fir, pine, and cypress.²⁰¹

2.3 *Exploiting Forests for Shipbuilding*

2.3.1 *Forest Exploitation*

It has been shown that forest coverage might change with time, and often by human interference. Forests are economic spaces that humans have exploited or promoted for both sustenance and surplus. In order to understand this interaction, first, different ways forested areas have been exploited must be pointed out. There are various practices which were established historically in the Eastern Mediterranean, and Dunn identifies these as: felling; the tapping to collect resin; gathering of arboreal parasites, crops, leaves or bark to produce natural dyes and tanning, such as kermes parasites from oak trees to produce scarlet dyes; pannage, hunting, coppicing and pollarding to promote regrowth.²⁰² Most of these practices did not drastically alter the forest areas; the most salient anthropogenic effect on these areas is in fact the clearing of forests to establish agricultural fields and the intentional cultivation of certain tree types. Examples include chestnut (*Castanea sativa*) and stone pine (*Pinus pinea*), since humans have altered the natural distribution of these species as to benefit from their by-products.²⁰³ However, in general, geology,

¹⁹⁸ Cohen and Cvikel 2019, 198. See Chapter 4 for a detailed analysis of some of these shipwrecks.

¹⁹⁹ Meiggs 1982, 86.

²⁰⁰ Mikesell 1969, 20.

²⁰¹ Mikesell 1969, 20.

²⁰² Dunn 1992, 225.

²⁰³ Di Pasquale et al. 2004, 13.

topography, climate (including precipitation and other meteorological factors) and soils are the base determinants of where and how well different plant types grow.²⁰⁴

Therefore forest exploitation does not necessarily mean the felling of the trees and exhausting the forest, but in fact is an issue of management: in cases where silviculture techniques were employed to exploit the tree, coppicing, suckering, pollarding and shredding are mentioned (Figure 2). Coppicing is cutting the trunk of a tree until the very base which is called the stool and allowing it to regrow from this base; pollarding is very similar to coppicing but the remaining tree after this process is 3-4 meters.²⁰⁵ Shredding is the cutting of the side branches of a tree, allowing it to become taller.²⁰⁶ Different species of trees give different reactions to being cut, “Some species just die whereas others sprout from the cut surface or produce root suckers.”²⁰⁷ Here, the difference between timber and wood can also be pointed out. Timber is obtained by felling large trees used for construction elements such as beams and planks.²⁰⁸ Wood, on the other hand comes from coppicing pollarding, and was used for charcoal or firewood which is necessary for industrial uses such as metal smelting, glass making, oven hearth pottery making as well as cooking and heating.²⁰⁹ It must however be noted that the uses of firewood and charcoal is different, charcoal is required for high-heat technological processes such as smelting, and goes through an additional process which drives off water and organics to leave a carbon based product.²¹⁰ This is in fact in line with the way the Roman jurists distinguished these two raw materials, *materia* - timber for building (construction, shipbuilding, furniture, mine shoring, barrels, etc.) - and *lignum*, firewood.²¹¹

²⁰⁴ Veal 2019, 13.

²⁰⁵ Grove and Rackham 2001, 48.

²⁰⁶ Grove and Rackham 2001, 48.

²⁰⁷ Di Pasquale et al. 2004, 14.

²⁰⁸ Grove and Rackham 2001, 55.

²⁰⁹ Grove and Rackham 2001, 55.

²¹⁰ Veal 2019, 11.

²¹¹ Wilson 2012, 139.

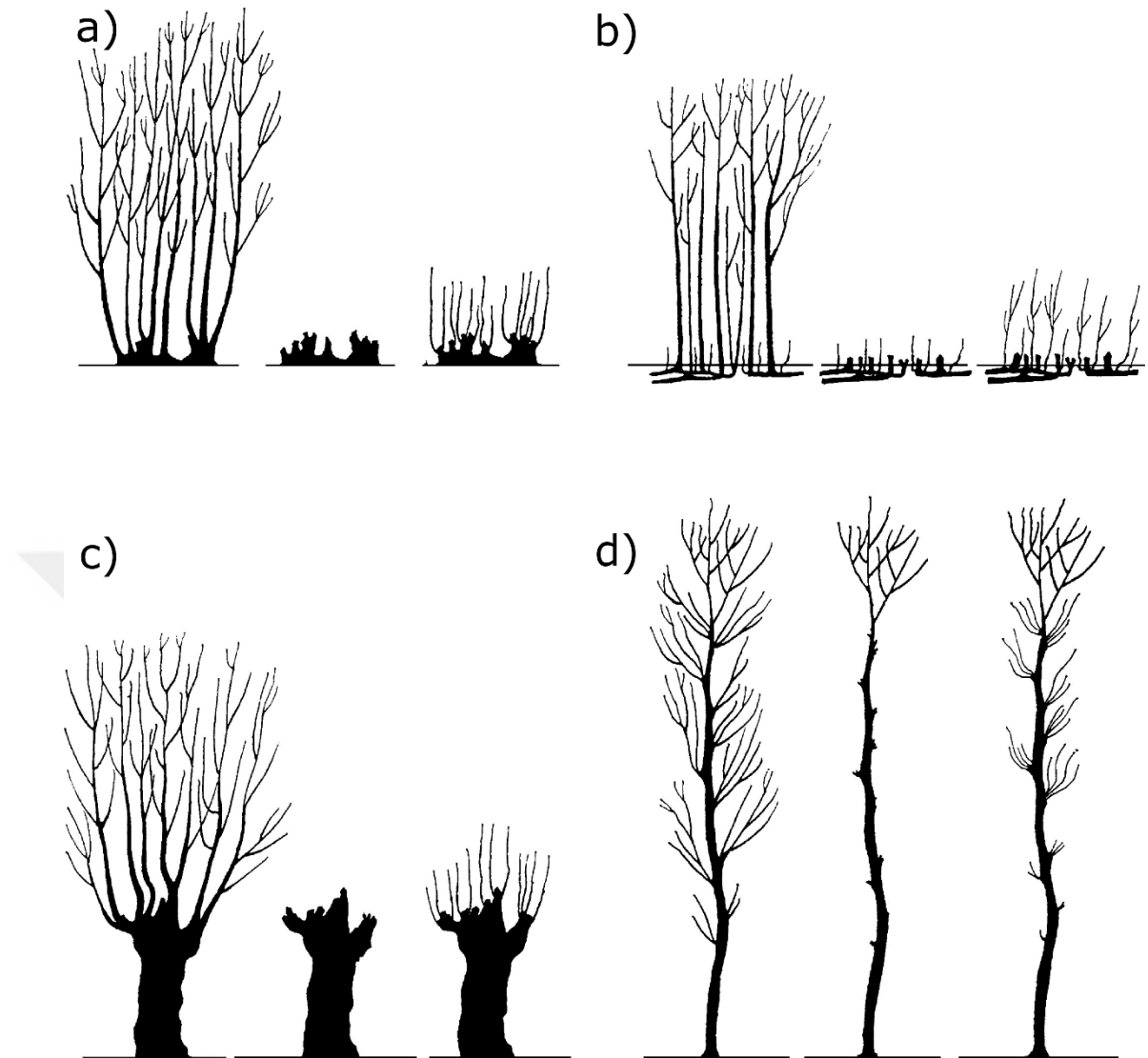


Figure 2 Major silvicultural techniques in Mediterranean woodlands. a) coppicing b) suckering c) pollarding d) shredding (Di Pasquale et al. 2004, 15.)

2.3.2 *Forest Exploitation and Economy of Byzantium*

These practices and techniques outlined above were also utilized by the Byzantines to exploit various sources of forests and uncultivated areas. Mastic for example, which is a by-product of mastic tree was under imperial monopoly.²¹² The selling of pitch, which is made from pine resin was also regulated by the state, in the *Book of the Eparch*, “dry and liquid resin (ζηράν πίσσαν καὶ υγράν)” was allowed to be sold by the grocers (Eparch,

²¹² Balard 1978, 742-6.

13.1). In the light of these, it can be argued that most of the practices which are even today used in the Mediterranean basin were also utilized during the Byzantine period.

Laiou argues that the uncultivated lands were an important part of the economy of especially the middle and late Byzantine villages.²¹³ She emphasizes that these areas did not only provide firewood for the hearths of the villages, but also timber for sale, acorns for tanning, pig feeding, dyes of various kinds, and medicinal plants.²¹⁴ Lefort also affirms the economic importance and exploitation of these areas, and points to an inventory that entered the number of trees in oak plantations.²¹⁵ In addition to these, two entries from a Middle Byzantine law code, the *Nomos Georgikos* (Νόμος γεωργικός) known as the Farmer's Code from 8th century CE might reveal details about forest exploitation:²¹⁶

39. If a man is cutting a branch in a thicket and does not pay attention, but it falls and kills an ox or an ass or anything else, he shall give soul for soul.

40. If a man is cutting a tree and unwittingly drops his axe from above and slays another's beast he shall give it.²¹⁷

The axe is the oldest tool that was used to fell trees.²¹⁸ Ovid, Roman poet (43 BCE – 17/8 CE) records the felling of a tree; “(...) and at length the tree, weakened by countless blows and drawn down by ropes, fell and with its weight laid low a wide stretch of woods around” (Ov. *Met*, VIII. 775). This can also be observed from the *Farmer's Law*, where the practice that is being described is most probably pollarding or shredding, the wood cutter is clearly on top of the tree in section 40 quoted above, and in 39 the branches are being cut, and the tree is not being felled completely. The use of axe for woodcutting is also observed from another entry of the *Farmer's Law*:

22. If a farmer at digging-time steals a spade or a hoe, and is afterwards recognized, let him pay its daily hire twelve folles; the same rule applies to

²¹³ See Laiou 2013 for the full discussion on middle and late Byzantine villages. These were called “the commons” in Northern Europe in comparison to the forests, which were a legal category.

²¹⁴ Laiou 2013, 45-6.

²¹⁵ *Patmos* II, no.50 (1073) in Nystazopoulou-Pelekidou 1980.

²¹⁶ Ashburner 1910, 85.

²¹⁷ Ashburner 1912, 91.

²¹⁸ Ulrich 2007, 22.

him who steals a pruning-knife at pruning-time, or a scythe at reaping-time, or an axe at wood-cutting time.²¹⁹

2.3.3 *Acquiring Shipbuilding Timber*

The supply of shipbuilding timber therefore should be considered in this framework of forest exploitation. However, the supply of timber for shipbuilding had a different nature than several other activities, such as acquiring firewood. For shipbuilding, both the durability of the tree species and the shape of the tree was important. Some parts of the ship, such as the frames, required curved timbers called compass timbers –which are naturally curved timbers can be used for frames, distribute the stress better than worked straight timbers, which can crack and split along their wood grain– were easier to find in the Mediterranean basin and could be obtained even from naturally curved parts of certain species of trees. Other parts of the ship, however, required long and straight (for masts) and thick (for keels) logs.²²⁰ Therefore the felling of trees for shipbuilding depended largely on the parts of the ship that were needed.

The exploitation of forests also depended on the commissioner of the ship as well. Loewen describes Spanish shipbuilding ordinances of 1613 and 1618 which describe the timber supply for a state arsenal. The arsenals would acquire the entire tree and use its parts for several ships, sometimes stockpiling timber, whereas for private construction the trees were harvested for one ship and often worked at the felling location as well to reduce transportation costs.²²¹ From this, it can be argued that the state shipbuilding and private shipbuilding would also affect the forested areas in different ways and at different scales; while the state could commission the construction of an entire fleet, private shipbuilding was often constrained by the more limited economic capacity of the patrons. There is also a possibility of a lumber storage depot in Constantinople during the Byzantine period, as examples of such practice is evident by the *vestiarion*, a storage for various military and naval equipment and materials.²²²

²¹⁹ Ashburner 1912, 89.

²²⁰ Grove and Rackham 2001, 168.

²²¹ Loewen 2000, 144.

²²² Cosentino 2018, 336.

Shipyards and arsenals of course were the final destination of shipbuilding timber. There are two terms that the Byzantine sources use in regard to shipbuilding facilities: *neorion* and *exartysis*.²²³ While *neorion* could also simply refer to a port, *exartysis*, which derives from “equipment” and thus means outfitting a ship, is exclusively used for shipbuilding and outfitting purposes.²²⁴ Ahrweiler suggests that these arsenals were not stationary and could relocate if the previous location is threatened by the enemy. It must also be pointed out that these terms refer to the naval shipbuilding centers for the fleets, but as Ahrweiler suggests, the people who would be in charge of the building of the provincial fleets at the major naval bases such as Constantinople, Rhodes, Smyrna, Cyprus, or Antalya would be the local shipwrights who also work for the local merchants and fisherman.²²⁵ This is also evident from the mention of local boat types in the registers of provincial armies, boats that were built by the shipwrights of the region.²²⁶ Local boats could be used for transport and also serve as a model for the warships built by local shipwrights. Morrisson records that due to their high consumption of wood, arsenals would be situated in regions with abundant forest resources.²²⁷ Ahrweiler had proposed a similar location of shipyards, in the region of port cities, however at a closer proximity to the forest resources.²²⁸ Kalligas, for example, writes that the shipyards of Monemvasia were at the harbor of Yerax, 14 km to the north, closer to the forest resources but still at a harbor in 10th century.²²⁹

Grove and Rackham, on the other hand, emphasize that the timber for shipbuilding could be shipped from longer distances to a dockyard.²³⁰ It must also be remembered that shipbuilding activities are usually not very visible in the archaeological record. Grove and Rackham write about their insights from a shipyard from South Western Turkey in 1996, where ships were not necessarily built at docks but on any available ground, leaving near to no archaeological trace of the activity.²³¹ It is therefore not easy to assume any

²²³ Ahrweiler 1966, 420.

²²⁴ Cosentino 2018, 335.

²²⁵ Ahrweiler 1966, 425.

²²⁶ Ahrweiler 1966, 425.

²²⁷ Morrisson 2016, 112.

²²⁸ Ahrweiler 1966, 426.

²²⁹ Kalligas 1990, 53-4.

²³⁰ Grove and Rackham 2001, 167.

²³¹ Grove and Rackham 2001, 168.

location for Byzantine shipbuilding facilities unless it was recorded in literary sources, or remains of rock-cut slipways or ship sheds can be dated to the Byzantine period. Although Vitruvius suggests that shipyards should not be made with wood due to the possibility of fire, the remains of these structures are not very visible today (Vitr. *De arch.* XII. xii. 7). The forested regions, however, might have been more suitable for this than embarking on long distance timber trade especially for private shipbuilding.

The supply of wood and lumber was also a part of compulsory public services. The peasantry was expected to perform labor services, the *angareiai* could include the cutting-down and transporting of wood, and in some cases shipbuilding.²³² Exemptions however were given to certain officials or men of learning, which included the exemption from the obligation to contribute boards or wood (*Cod. Theod.* XI, 15; XI, 18). The supply of wood overseas was also incentivized, it is recorded that “African shipmasters who convey wood suitable for public uses and needs” were given privileges (*Cod. Theod.* XIII. 5. 10).

The *dendrophorus* was a member of the guild of which the compulsory public service was the transportation of wood (*Cod. Theod.* XIV.8). The roots of this category might have been in the reformation of the cult of Magna Mater (Cyblee) by Emperor Claudius (r. 41-54 CE), and the creation of the *dendrophoroi*, who carried the sacred pine tree in the yearly procession for the goddess.²³³ Wilson, by correlating the heavily wooded areas and the inscriptions that mention the *dendrophoroi*, argues that they were lumberjacks or loggers in charge of logging and shipping of timber for shipbuilding and construction.²³⁴ It is not far-fetched to assume that the existence of a similar guild continued in the Eastern Roman Empire.

On the other hand, some incidental references also show different types of ownership and procurement of shipbuilding wood. In the writings of John Moschus, a Byzantine monk who lived from late 6th century to early 7th century for example, a miracle regarding wood is narrated. Miracle 190, “The Miracle of Some Wood Given to Abba Brocha”, recalls the story of an abbot who in the vicinity of Seleucia was building a cell for himself,

²³² Harvey 1989, 108.

²³³ Verboven 2016, 177.

²³⁴ Wilson 2012, 140.

and needed timber to cover its roof. Thus, he goes to Seleucia and asks it from Anatolios, a magnate, who in a way to mock the abbot tells him to a certain mast he in front of his house. This mast is supposed to be for a merchant ship of “50.000” capacity. It is important to emphasize that this magnate had timber in his possession, in fact lying around his house, either for his ship, or to sell to other shipowners or shipwrights. Also, Anatolios, mesmerized by the fact that the abbot carried the mast on this back, gives him “as much wood as he required” (*Prat. Spirit*, 190). This account shows that powerful individuals also possessed timber, although it is not clear if they were trading this material or using for their private needs. It can be assumed that both were the case in specific instances.

This brief outline of the exploitation of forests especially for shipbuilding shows that timber was in fact integral to the Byzantine economy. It was not only supplied from the uncultivated lands of the empire through public services, but its long distance trade was also at times subsidized by the state.

2.4 Shipbuilding Timber in the Ancient Sources

In the rest of this chapter, the discussion of the relationship between the people and the forests in Byzantium will be narrowed to the procurement of shipbuilding timber. Since timber is a perishable, organic material, and the archaeological remains -except for cases of survival in building structures or as charcoal- are very scarce in most environments.²³⁵ The written evidence as outlined in Chapter 1 mentioning the exploitation of timber is not common either. However, the texts which directly refer to shipbuilding timber from the Greek, Roman and Byzantine periods can be surveyed in a chronological manner in order to understand better the preferences, logistics and prices of shipbuilding timber.

It must be stressed that texts which explicitly describe the cutting of timber for shipbuilding or shipbuilding methods in general are very rare, and often has a military nature. Zucker argues that “Literary data expresses what professionals decided to formalize and to entrust to written communication”, which was not a widespread

²³⁵ Veal 2013, 37 has pointed out that charcoal is not yet routinely collected by all excavators. See Veal 2013 for a detailed analysis of charcoal research in the context of ancient fuel.

phenomenon.²³⁶ The technical developments in areas such as seafaring show that technical knowledge was seldom transmitted through literary means. One example is the lack of architectural treatises after Vitruvius (1st century BCE) which describe in detail how to construct buildings, in sharp contrast with the amount of architectural construction and innovation around the empire.²³⁷ Therefore, it can be assumed that most of the knowledge on shipbuilding regarding the choices of timber was passed on orally also shown by ethnographic accounts from later periods. Research in the Black Sea coast of modern Turkey has shown that the traditional wooden shipbuilding was taught through a mentorship system.²³⁸ The transmission of shipbuilding knowledge until 20th century had remained oral in the region.²³⁹ The shipyards have also traditionally been owned by families.²⁴⁰

It is also reasonable to assume that the shipwrights were illiterate.²⁴¹ Browning also points that mostly the classes that needed literacy, such as the bureaucrats or the families of high status, learned to read and write.²⁴² Aside from a few exceptions, this was also the case for book owning.²⁴³ Zwick argues that “free choice of construction technique would have been very much constrained by the conformist bias of the local shipbuilding tradition.”²⁴⁴

It must also be pointed out that shipbuilding especially in the context of warship building was a valuable knowledge; it was seen as a secret by the state and was protected by law. In a passage from the Epanagoge (Ἐπαναγωγή) of Basil I (r. 867–886), a legal code compiled c. 879 CE, as well as the Synopsis Minor, which was again a compilation of previous law codes produced in the second quarter of the 13th century under John Ducas Vatatzes (r. 1222 –1254) include:

²³⁶ Zucker 2020, 300-1.

²³⁷ Schibille 2009, 360. Julian of Ascalon's “Treatise of Construction and Design Rules” from 6th century Palestine might be an example to this genre; however it is comprised mostly of laws regarding land use in cities and not technical details of architectural construction. See Hakim 2001.

²³⁸ Davulcu 2015, 104.

²³⁹ Davulcu 2015, 106.

²⁴⁰ Davulcu 2015, 106.

²⁴¹ Zwick 2013, 54

²⁴² Browning 1978, 40.

²⁴³ Browning 1978, 42.

²⁴⁴ Zwick 2013, 54.

ιζ'. Ναύκληρος ὁ βαρβάρους κατασκευάζειν διδάσκων ναῦς ἤγουν ὁ πλοῖα ποιεῖν ἔθνεσιν ἀλλογενέσιν ὑποδεικνύς, κεφαλικαῖς τιμωρίαις ὑπόκειται, ὡς τοῖς τῶν ῥωμαίων ἐχθροῖς διδοὺς ὅπλα καὶ ἰσχυροὺς ἐκείνους κατὰ τούτων ἀπεργαζόμενος.²⁴⁵

17. The captain who teaches to barbarians how to build a ship or rather who shows to other nations how to make a vessel is subject to capital punishment, as those who give weapons to the enemies of Romans and in this way make them stronger.

Thus, it is not surprising that details of shipbuilding was not recorded in literary sources. Several sources, from not only the Byzantine but earlier Classical and Roman periods, however, reveal information about the timber types used in shipbuilding.

There are several ancient sources, from 4th century BCE to the later Roman period, mentioning the usage of forest products for shipbuilding and each one of them has the perspective of their relevant author. Theophrastus, for example, can be described as a botanist, whereas Pliny the Elder, in addition to transcribing the work of ancient authors, also related specific events that he witnessed in his lifetime; and Vegetius wrote primarily from a military perspective. Although a manual on how to build merchant ships or warships might have been written, it does not survive today, and several of these authors sporadically mention shipbuilding. Most of them focus on naval constructions that might have been the concern of the states or patrons rather than small-scale roundship building which may have been more localized. These sources must be evaluated, however, from a nautical perspective, and the chapters as well as passages related to shipbuilding timber should be analyzed to understand the possible practices of the period.

2.4.1 *Problems with the Identification of Timber Types*

Before analyzing the ancient sources, some remarks must be made about the terminology that the authors use to mention different species and genus of trees. The Greek names or the later Latin translations of tree species does not necessarily correspond

²⁴⁵ This can be found in both Επαναγωγή title 40 in Zepos, *Jus* 2:362 and *Synopsis minor* N, chapter 17. in Zepos, *Jus* 4:471.

to modern counterparts.²⁴⁶ Meiggs analyses several problems regarding this issue, and the differentiation between cedar and juniper is especially relevant to the study of shipbuilding timbers. Cedar and juniper in Greek and Latin are both called *kedros* or *cedrus*.²⁴⁷ At the same time, a specific type of juniper in both languages are given separate names, *arkeuthos* for Greek and *juniperus* in Latin.²⁴⁸ Therefore, it is not easy to understand which of the species the author is discussing. Meiggs' solution for this problem is the analysis of the context to determine which tree was being referred to. Cedar is superior to juniper in girth, and therefore if that is emphasized in the text, the word is more likely to be referring to cedar. On the other hand, geographical association might also indicate whether cedar or juniper is mentioned. For example, cedars have been long associated with Lebanon, from the very early epics of Gilgamesh to various religious texts; “The righteous shall flourish like a palm tree, He shall grow like a cedar in Lebanon.” (Psalm 92:12,).²⁴⁹ It is not safe to assume that in all cases if the species is mentioned in the context of the specific geographical region it is often related to –exported cedar to the Levant could for example be called “cedar of Lebanon” based on convention– such as in the case of cedars of Lebanon. Although this might not be taken as an evidence for determining the type of tree, it still is an important clue in translations.

2.4.2 Theophrastus

Theophrastus' (c. BCE 371– 287) *De causis plantarum* and *Historia plantarum* are known so far to be the first attempt to classify trees.²⁵⁰ He lived most his life in Lesbos and Athens during late 4th and early 3rd century BC, and later Greek and Latin authors accepted him as an authority on botany.²⁵¹ In *Historia plantarum*, Book V is devoted to the timber of various trees and its uses (Theophr. *Hist. pl.* V); meanwhile a short section in this book focuses on shipbuilding timber (Theophr. *Hist. pl.* V.vii.1-8). However, his

²⁴⁶ On naming plants in Greek see Irwin 2016, 266-67. Also see Meiggs 1982, 410-22 “Appendix 3 Confusion of Species on the Greek and Latin” translations of certain species between Theophrastus and Pliny the Elder.

²⁴⁷ Meiggs 1982, 410.

²⁴⁸ Meiggs 1982, 410.

²⁴⁹ For the associations of Lebanon with cedar, see Meiggs 1982, 49-87 and Liphschitz 2013, 50-6, 70.

²⁵⁰ Meiggs 1982, 17.

²⁵¹ Meiggs 1982, 17.

work suffers from various misconceptions, such as the obvious analogies between the plants and the animals, where female trees are fruit bearing and fragile, while male trees are much harder to fell (Theophr. *Hist. pl.* III. 9.6).

Theophrastus' short chapter on shipbuilding timber, for being in fact one of the longest references in ancient scholarship, should be examined in detail. His narration divides ship types into merchant and warships, and he does not only mention the hull and the keels of the ships, but other parts which cannot be precisely translated as his text is the only surviving ancient material referring to them. However, it is significant that he emphasizes the important properties of the wood to be durability and strength, as well as weight.

Now silver-fir, fir and Syrian cedar are, generally speaking, useful for shipbuilding; for triremes and long ships are made of silver-fir, because of its lightness, and merchant ships of fir, because it does not decay ; while some make triremes of it also because they are ill provided with silver-fir. The people of Syria and Phoenicia use Syrian cedar, since they cannot obtain much fir either; while the people of Cyprus use Aleppo pine, since their island provides this and it seems to be superior to their fir. Most parts are made of these woods; but the keel for a trireme is made of oak, that it may stand the hauling; and for merchantmen it is made of fir. However, they put an oaken keel under this when they are hauling, or for smaller vessels a keel of beech; and the sheathing is made entirely of this wood. (Theophr. *Hist. pl.* V.vii.1-3).

Theophrastus refers to fir (*Abies*), which he says is useful to build merchant ships with, and silver-fir, which is light and therefore more suited for warships.²⁵² He also mentions silver fir to be the greatest lengths and the straightest growth, which makes it suitable for making yardarms and masts, and the laminated structure of its wood makes it suitable for making oars (Theophr. *Hist. pl.* V.i.6). It is important for oars to have a regular

²⁵² To make it easier for the oarsman to row at a significant speed and maneuver, the ship had to be kept as light as possible. See Section 4.3.3, Longships in this thesis for a detailed discussion of the types of trees used in the Mediterranean for galley construction.

wood grain to avoid any weak points where they can break. Oars especially were crucial for naval fleets; during Theophrastus's time, one of the most common war galleys, *triērēs* had 170 oars per ship.²⁵³ Here he might be distinguishing between silver fir (*Abies alba*) from the rest of the fir (*Abies*) family. Cedar is very easily confused with juniper, and the tree that the word refers to often depends on the context. Here Theophrastus includes "Syrian" cedar, which was used by the people of Syria and Phoenicia. Meiggs sees this geographical reference as an indication of the species referred here being cedar and not juniper as Theophrastus creates this relation between the specific region and cedars elsewhere (Theophr. *Hist. pl.* V.viii.1; III.ii.6).²⁵⁴

Meanwhile, the exact type of cedar is not determined from the information he provides. Lastly, he relates that in Cyprus, Aleppo pine (*Pinus halepensis*) is used as it is superior to the fir there. From this it can be understood that he uses "fir" as a general term for different fir types except for silver fir, and that Aleppo pine (*Pinus halepensis*) was used in Cyprus as shipbuilding timber. He says that most parts of the ships were made from these materials except for the keel, this bottom part of the ships are made from different materials as it is often damaged by when the ship is hauled on the beaches. For the keels of *triremis* he suggests using oak (*Quercus*), which is a durable hardwood, however it might have been too heavy for warships and long pieces of wood necessary for this component of warships cannot usually be obtained from oaks. He comments that for merchant ships the keel is made of fir (*Abies*), but an oaken keel is put under it when hauling, or for smaller vessels the keel should be made of beech (*Fagus*). The rest of his account is of other parts of the vessel that must be made from different materials:

In merchant ships the internal woodwork is made of mulberry or ash or elm or plane since it must be cheap and tough. Plane wood is the worst because it rots quickly. Sometimes the internal part of *trireis* are made of coastal pine as well, because of its light weight. But the stempost, which adjoins the breastwork, and the bow timbers are made of ash and mulberry and elm, since these parts have to be tough. (Theophr. *Hist. pl.* V.vii.1-3).

²⁵³ Morrison and Coates 1996, 260; Morrison et al. 2000, 131-33.

²⁵⁴ Meiggs 1982, 411.

He mentions is the *torneia* *τορνεία*, which was translated as “bentwood” by Hort in the Loeb edition, can be interpreted as being a crooked timber piece, and Theophrastus is the only ancient reference to this part of the ship using this specific name. The word *torneia* might also be a corruption of *enteroneia*, signifying the internal woodwork of the ship, thus the framing, a definition used by Morisson et al in their translation.²⁵⁵ Whichever component *τορνεία* is, it must be strong and tough, for which Theophrastus recommends mulberry (*Morus*), manna-ash (*Fraxinus ornus*), elm (*Ulmus*), or plane (*Platanus*) (although plane decays faster), and for warships Aleppo pine (*Pinus halepensis*), as it is lighter compared to the other types.

Theophrastus’ account of shipbuilding timber ends here, but it is important to highlight his differentiation between warships and merchant ships, as well as his detailed account of various parts of the ship. In the following section, which is in fact titled “Of the woods used in house-building” he also discusses the seasoning of the shipbuilding timber.

But for shipbuilding, because of the need for bending, it is necessary to use sappier wood (though when it is a case of stopped joints the drier the wood the better). The fact is that (hull) planking shows gaps [between planks] when it is new, but when the ship is launched the planks absorb water, close up and are watertight, except in the case of timber which has been completely dried out. In that condition planks do not make a close joint, or not as well as they would if the wood was not completely dried out. (Theophr. *Hist. pl.* V.vii.3-5)

This account shows that the timber when it was still green and not seasoned, it could be bent into shapes; however, if a joint is to be used, then it has to be drier for it to hold. It is then logical for dried wood to swell when in the water, compressing the joints, which would not happen if the wood were still green and moist.

²⁵⁵ Morisson et al. 2000, 181.

2.4.3 Pliny the Elder

Another author dealing with the subject of timber is Pliny the Elder (c. 23–79 CE), a Roman author and naval commander who wrote *Naturalis Historia* in 1st century CE. He devotes the 16th book of this work to the discussion of forest trees (fruit-bearing trees are discussed in another section). Meiggs points out that his account mostly derives from Theophrastus, but includes a number of mistranslations and misunderstandings of his account.²⁵⁶ However, he was the *praefect* in charge of the naval fleet at Misenum and therefore likely had first-hand knowledge of the timber used in shipbuilding as well as relating specific events related to the subject (Plin. *Ep.* LXV).

Several sections in his work is about the process of forest exploitation for shipbuilding, and certain points that he makes should be emphasized. For the felling of trees, he describes the process of seasoning them, where the tree trunk is left “standing” to reduce the moisture (Plin. *HN.* XVI.74). This is followed by his accounts of the instances when this practice was not observed, which he refers to as emergencies. In the first Punic War, the fleet was constructed in sixty days from the time the timber was cut, and in the Second Punic War, only in forty days, as in both occasions a fleet had to be constructed very quickly to oppose the Carthaginians (Plin. *HN.* XVI.74). From this account it is understood that using freshly cut trees for ship construction is not ideal, and as will later be discussed, the state especially for its own provision cuts and seasons timber for at least a year, depending on the species.²⁵⁷

Pliny makes several references to the use of timber for shipbuilding. He indicates that fir is in great demand for shipbuilding (Plin. *HN.* XVI. Xviii.41-2). He later comments that (in line with Theophrastus) fir is preferred for making the masts and yards of ships, because it is light, straight, and long (Plin. *HN.* XVI.lxxv.195). Different from the earlier accounts of Theophrastus, he also adds larch (probably *Larix europaea*) to this type of trees. He goes on to give examples of fir and larch, in height that he found impressive. One is a log of larch brought by Emperor Tiberius (r. 14 – 37 CE) and was 120 feet long. One example is the fir that was used for the mast of the ship which brought an obelisk

²⁵⁶ Meiggs 1982, 24.

²⁵⁷ Softwoods for example takes less time to dry compared to hardwoods.

from Egypt on the orders of Caligula, which was admired by many in Rome. This is the same ship that was sunk in the harbor of Portus after being filled with the hydraulic concrete made from sand from Puteoli, in order to erect the port's lighthouse (Plin. *HN*. XVI.lxxvi.202).

Pliny also makes one reference to the use of cedar for shipbuilding without mentioning specific species. He records that in Egypt and Syria, due to the lack of fir, the kings used cedar to build ships. The largest recorded cedar according to him came from Cyprus and was used to make the mast of a galley for Demetrius: it was one hundred and thirty feet in length. (Plin. *HN*. XVI.lxxvi. 203).²⁵⁸ Meiggs comments about this passage, stating that Pliny's account was for a long time accepted as a mistake, as cedar trees were not thought to be found in Cyprus. However, with the discovery of cedar groups on the island in 1879 in the Troodos mountains by botanists (possibly *Cedrus brevifolia*, endemic to the island), his assertion was proven to be true.²⁵⁹

Like Theophrastus' account, there are several references to trees that are used for various parts of the ship. For example, he mentions that palm leaves are dried and split in order to make ropes, which is specifically durable in water, which might indicate the usage in rigging of ships (Plin. *HN*. XVI.xxxvi.89). An interesting passage concerns cornel (*Cornus mas*) which he says is used to make wedges for splitting wood, and pins or bolts, which have all the hardness of those of iron (Plin. *HN*. XVI.lxxvi.206). Regarding teredo worms or shipworms (*Teredo navalis* sp.), he mentions that although almost all wood types are vulnerable to teredo worms in the sea: larch is the most affected species (Plin. *HN*. XVI.lxxix.219). He also explains the production of tar and pitch in three chapters (Plin. *HN*. XVI.xxi-xxiii) describing which trees are used for tar and how it is collected, as well as mentioning that it is used to coat ships.

When Theophrastus and Pliny the Elder are compared, it can be said that in contrast to Theophrastus, the latter does not devote a specific chapter to discuss timbers suitable

²⁵⁸ Pliny does not give information about "Demetrius". It might have been Demetrius I of Macedon, who was known as the The Besieger (*Πολιορκητής*), who defeated the Ptolemaic Navy at the Battle of Salamis and conquered Cyprus in 306 BCE and was known for his naval expeditions. His biography was written by Plutarch later, in 1st century CE. See Plut., *Vit. Demetr.*

²⁵⁹ Meiggs 1982, 411.

for shipbuilding, but he refers to forest trees at many points in his text. The examples he gives show a certain familiarity with shipbuilding, of which he presumably had more experience. More anecdotes are also included in his narration concerning both the Roman Empire and the Hellenistic Kingdoms, and about specific trees that were found to be impressively tall or wide.

2.4.4 Vegetius

An account from the Late Roman period that must be mentioned on shipbuilding timber is given by Vegetius, a Roman author from the late 4th century CE. His military manual *De Re Militari* includes a section on the navy and how naval ships are built. While discussing shipbuilding, he first indicates that the quality of the material is crucial, and in fact more important than the building material for houses. For warships he recommends cypress, domestic or wild pine, larch, and fir. (Veg. *Mil.* IV.34). Like Pliny the Elder, he also describes the seasoning of timber, and warns that green wood should not be immediately installed into ships as it will form cracks and must have some moisture removed first (Veg. *Mil.* IV.36).

2.4.5 The *Taktika* of Leo VI

Another military manual which mentions the fittings of warships is the *Taktika* of Emperor Leo VI “The Wise” (r. 886-912 CE) (*Ναυμαχικά Λέοντος βασιλέως*). Constitution 19 of this work concerns “Naval Warfare”, in which important details about warship building can be traced. First of all, he mentions that spares of most pieces of equipment should be kept on board; “this includes tillers, oars, pegs for oars, ropes, pulleys and their sails, yardarms and furnishings (...)” (Leo VI. *Taktika*. XIX.5). Therefore, ideally a ship would be equipped with double the necessary equipment. In addition to this, constant repair on board is also expected; , a shipwright is to be present on board at all times, with his tools that include an adze, a drill, and a saw, and extra timber is kept on the ship for hull repairs, with planks, hemp, pitch and liquid pitch (Leo VI. *Taktika*. XIX.5). The weight of the ship is also emphasized: the manual mentions that it should be neither too heavy or too light, but should be in a balance, so that it is not slow when sailed and it can endure contact with waves or the enemy. (Leo VI. *Taktika*. XIX.4). This balance then has to include not only the choice of timber (which has been

emphasized to be light by the ancient authors) and also take into account all the extra equipment that needs to be kept on the ship. The concern of the manual is very practical and is related to the needs on board during an expedition rather than the construction of the ship. However, it must also be acknowledged that Emperor Leo VI derived his knowledge of naval warfare from “ancient” tactical manuals and his *strategoi* (military commanders) and did not have first-hand experience of naval campaigns himself.²⁶⁰

2.4.6 *Geoponika*

Geoponika is an agronomic work compiled during the 10th century in Constantinople commissioned by emperor Constantine VII (r. 913- 959). Constantine VII, who was the son of Leo VI, is associated with various scholarly works which were compiled during his reign, such as *De administrando imperio* and *De cerimoniis*. *Geoponika* on the other hand is a farming manual, compiled from the works of ancient authors.²⁶¹ Dalby assumes that *Geoponika* largely derives from Roman agricultural traditions, pointing to a continuation of certain practices.²⁶² Dalby in fact asserts that the farming textbook by Columella (mid-1st century CE) and a guide by Palladius (4th century CE) were the main sources for the *Geoponika*.²⁶³ In Book II, for example, when information on how to plant a specific tree is discussed deriving from an earlier source (such as *Geoponika* XII.5, “Planting cypress, Didymus”), the author first presents an ancient myth about the tree (*Geoponika* XII.4, “Story of the cypress”). Although the book does not mention the usage of trees for carpentry in general, or shipbuilding in specificity, it refers to several by-products such as resin from cedar trees (*Geoponika* XVI.18.1). In this sense, it reflects the exploitation of smaller forest by-products during both the Roman and the Byzantine periods.

2.5 *Deforestation*

Hadrian’s inscriptions for the ownership and regulation of exploitation of the mountains of Lebanon, on the other hand, bring about an important factor in

²⁶⁰ Pryor and Jeffreys 2006, 176.

²⁶¹ Kaldellis 2015, 36-7.

²⁶² Dalby 2011, 13.

²⁶³ Dalby 2011, 13.

understanding timber trade: deforestation. Mikesell and Hughes see the precaution that Hadrian took as an indication of the forests being under threat of exhaustion, and Mikesell states that most of the regions where inscriptions have been found today are devoid of any forests, which might indicate erosion and the lack of forest regeneration as well.²⁶⁴ Meiggs, on the other hand, disagrees with this statement, and proposes that the inscriptions were only to make imperial ownership more explicit in order to preserve crucial imperial resources, since it takes a very long time (almost 30 years to grow up to 10 meters) for cedars to grow into the lengths useful for building activities, and possibly even more for shipbuilding.²⁶⁵ Harris however negotiates both extremes, and proposes that Hadrian's inscriptions were not completely pre-emptive, and not necessarily caused by risk of deforestation but for "military preparedness, Mediterranean shipping and imperial building plans."²⁶⁶

The extent of deforestation around the shores of the Mediterranean in antiquity has been an ongoing debate, and scholars have tended to analyze the accounts of ancient authors and, more recently, palynological and other environmental data as discussed in Section 2.1. It has been proven to be unrealistic to try to understand deforestation solely through the writings of ancient authors. One example is the citing of a passage by Plato:

"But in the primitive state of the country, its mountains were high hills covered with soil, and the plains, as they are termed by us, of Phelleus were full of rich earth, and there was abundance of wood in the mountains." (Pl. *Criti.* 111 a-c)

Hughes, for example, refers to this passage and argues that Plato "observed" deforestation in Attica.²⁶⁷ Horden and Purcell, on the other hand, argue that this passage in fact employs the trope of an "imaginary prehistoric geography", and point out that it is narrated in the same Platonic dialogue as Atlantis.²⁶⁸ Harris also agrees with the point that it is not possible to take Plato's narration as evidence for deforestation in Attica, but

²⁶⁴ Mikesell 1969, 19; Hughes 2005, 41.

²⁶⁵ Meiggs 1982, 87.

²⁶⁶ Harris 2013, 183.

²⁶⁷ Hughes 1983, 437.

²⁶⁸ Horden and Purcell 2000, 331.

argues that Plato was emphasizing the absence of tall trees, which Athens was importing for building and ship construction during this period/Plato's time.²⁶⁹

Another misinterpretation that Horden and Purcell point out is a reference to Strabo by Thirgood.²⁷⁰ Strabo relates about a mountain around the Strait of Gibraltar, "(...) to the mountain that lies above them, Abile by name, which abounds in wild animals and large trees." (Strabo XVII.iii.6) The word used by Strabo is *μεγαλόδενδρον*, meaning exactly "large trees". Thirgood however paraphrases this as "a mantle of great trees", exaggerating the original text.²⁷¹ This is also evident from his literary analysis of various ancient authors proposed that the glory of Classical Greece was at the expense of an ecological crisis.²⁷² Hughes and Thirgood draw a parallel between the "ruined cities and ruined land", claiming that the deforestation caused by the ancient civilizations triggered their decline.²⁷³ As Hughes also demonstrates, ancient texts about deforestation can be utilised to understand the sentiments they have hold towards the concepts of nature and forests, such as the sacralization of wooded areas.²⁷⁴ However, it is not realistic to try to understand deforestation from these sources as the motivation behind these texts. First of all, they might not have been recording deforestation, but presenting moral criticism through analogies, and secondly it cannot be determined if they had the knowledge of the previous forest coverage to write about the possible deforestation they have observed. Grove and Rackham also point out that it is never expressly stated in ancient texts that a forest had existed earlier and was not there during the writers' time.²⁷⁵

Another problem is the difference between deforestation as a wider ecological crisis and a lack of shipbuilding timber. Some authors fail to distinguish between general forest coverage and the available trees suitable for shipbuilding: especially long and tall trees have been a general exception in the Mediterranean.²⁷⁶ Theophrastus, for example, states "it is only a narrow extent of country which produces wood fit for shipbuilding at all",

²⁶⁹ Harris 2011b, 481-82.

²⁷⁰ Horden and Purcell 2000, 332.

²⁷¹ Thirgood 1981, 41.

²⁷² Thirgood 1981, 1-2.

²⁷³ Hughes and Thirgood 1982, 60, 75; see also Grove and Rackham 2001, 8-10.

²⁷⁴ Hughes 1983, 43.

²⁷⁵ Grove and Rackham 2001, 171.

²⁷⁶ Grove and Rackham 2001, 167.

which does not necessarily mean that these forests were exhausted, but shipbuilding timber is simply a more specific resource than general vegetal coverage (Theophr. *Hist. pl.* IV.v.5).²⁷⁷ Horden and Purcell also propose that the lack of timber for building and ship construction does not necessarily point to a lack of forest sources. These types of activities require special types of timber, especially wide and tall logs for galleys, while a wider range of timber types can be used for smaller vessels. Therefore, the extraction of only these types of trees does not necessarily indicate wider deforestation or an ecological crisis.²⁷⁸

In the light of modern-day developing countries that are still substantially wood-dependent, Veal proposes that around 90% of the wood that was harvested would be used as fuel, and the rest for other purposes.²⁷⁹ Therefore it can be assumed that the deforestation caused by periods of intensive building construction for navies was not regular but might have had effect on specific coverage, that is, trees of certain types, lengths, and widths, being felled within a short time of period. Additionally, Grove and Rackham observe that shipbuilding would not drastically alter the forest coverage of a region. For example, from their research conducted in 1996 in the region where the Bozburun shipwreck was found, they assume around 1500 ships (mostly of pine, between 25-31 m in length) to be built in 50 years. This would mean the consumption of about 18 km² of pine savanna, which is much less than the actual pine coverage of the region. They point out that a fire in 1996 destroyed the pine forests in a couple of days that shipbuilding could consume in over a century.²⁸⁰ It must however be pointed out that large naval and merchant fleets would have consumed more timber than 20th century wooden shipbuilding.

Most of the Mediterranean micro-regions were self-sufficient in the aspect of fuel sources, and Harris argues that there were two exceptions to this rule: mining and metallurgical activities and the demands of metropolitan centers.²⁸¹ These would be the

²⁷⁷ Hughes 1983, 437.

²⁷⁸ Horden and Purcell 2000, 336.

²⁷⁹ Veal 2013, 40.

²⁸⁰ Grove and Rackham 2001, 168.

²⁸¹ Harris 2013, 177. Horden and Purcell have defined Mediterranean micro-regions as “an extreme topographical fragmentation deriving ultimately from the tectonics of the region” Horden and Purcell 2020, 43.

major causes for wood shortages in relation to the continuous consumption. Shipbuilding timber, however, was -as stated- a different case, and Harris argues for fluctuations in the demand for shipbuilding. One example is Athens during the peak of its naval power in the 5th and 4th centuries BCE. During this time the forests of Attica were deprived of their tall trees, which would especially be used for constructing galleys; however these forests regenerated after the fall of Athens from prominence.²⁸² Athens therefore became dependent on outside sources for its navy's timber supply.²⁸³

Karathanasis, while discussing the role of timber in the diplomatic relations between Athens and Macedonia, proposes that almost the whole of Greek mainland had fir trees, while the ones from Macedonia had fewer knots, were taller and were more suitable for shipbuilding. This can be inferred from Theophrastus:

For even among those of the same kind those which grow in congenial places have less knots, and are taller and comelier: thus the silver-fir in Macedon is superior to other silver-firs, such as that of Parnassus. (Theophr. *Hist. pl.* I.ix.2).

The fir of this region was a hybrid of *A. alba* and *A. cephalonica*, called *A. borisiiregis*, and was superior as shipbuilding timber to the other trees that were available.²⁸⁴ Therefore, although other sources might have been acquired, Athens' foreign policy in the 5th century BCE shows their dependence on Macedonian timber sources.²⁸⁵ Thus, although Athens could acquire wood for daily sustenance, the Macedonian fir was more suitable.

2.6 Logistics of Timber Transport

One of the most important aspects in understanding the supply and trade of shipbuilding timber is the logistics of how it was transported. Long lengths of timber, especially when they had to be kept intact to be used in one piece on ship construction

²⁸² Harris 2011a, 123; 2013, 174.

²⁸³ See Karathanasis 2019 for the role of timber in the diplomatic relations between Athens and Macedonia.

²⁸⁴ Farjon 2017, 67.

²⁸⁵ Karathanasis 2019, 724.

such as the material for a mast, keel or trunks for hull planking are not very easy to transport. The location of their felling could be close to the seashore or further inland in a mountainous region. There are various ways of conveying timber to a shipyard, from wherever it was felled, and several sources from the Roman and Byzantine period provide details about the matter.

After the felling, the timber had to be transported, and the easiest method is to float logs on bodies of water such as rivers and the sea, either by driving them downstream or attaching logs to each other as a raft and drifting or pulling them. One of the earliest examples of this method can be found on the Khorsabad wall relief sculptures placed on the frontal facade of Sargon II's (721-705 B.C.) palace, today in modern Iraq. The reliefs show in detail of the shipment of timber from a depot to the building site by the river, focusing on the process and techniques of the loading, transporting, and disposing of the lumber.²⁸⁶ This method of transportation is also referenced in the Roman sources. Dionysius of Halicarnassus, while describing the abundant forests of Italy where timber suitable for shipbuilding would grow, adds that these sources were very easy to reach “owing to the multitude of rivers that flow through the whole peninsula and make the transportation and exchange of everything the land produces inexpensive” (Dion. Hal. *Ant. Rom.* 1. 37. 4). Vitruvius mentions that larch was too heavy to float on water so that when transported it had to be loaded on board ships or on rafts made of fir (Vitr. *De arch.* 2.9.14).

Strabo records similar practices in Asia Minor, while describing the forest exploitation for shipbuilding in the Black Sea region he points out the convenience of transporting the timber (Strabo XII, 3.12). It is mentioned here that transport was easy not only because they could be moved through rivers but also, they could be shipped along the coasts, which would also have been the case in the Aegean between the islands and the mainland as well as the southern Asia Minor coast. Ibn Said has also been mentioned to have described the cutting and floating of pinewood from the forests to the arsenal of Sinop.²⁸⁷ Later written evidence also shows that this practice of using the rivers to

²⁸⁶ Linder 1986, 273.

²⁸⁷ Redford 2014, 91.

transport timber continued. For the 15th century, there are Ottoman references to the taxation of the timber traffic on the Vardar River in Macedonia.²⁸⁸

Most of the time, in the mountainous ranges of northern and southern Asia Minor as well as Thrace, floating would have been possible, and since the various parts of the empire was connected through the Black Sea, Mediterranean and the Aegean, shipping would make transportation easier. When Pliny the Younger (AD 61-113) is advising Trajan to connect the lake in Nicomedia (Sapanca Gölü) with the Sea of Marmara, he asserts that “There is a sizeable lake not far from Nicomedia, across which (...) wood, and timber for building are easily and cheaply brought by boat as far as the main road; after which everything has to be taken on to the sea by cart, with great difficulty and increased expense.” If the lake had direct connection to the sea, he says, it would be more beneficial to everyone (Plin. *Ep.* X.41.1-2). Land transport was avoided whenever possible.

The carts that Pliny the Younger mention is another method of timber transportation, on land by beasts of burden. One of the earliest examples of this type of transportation is from an Egyptian story, the Report of Wenamun, from c. 1100 BCE.²⁸⁹ In the story preserved in papyri, Wenamun, a priest of Amun at Karnak, is sent to Byblos (modern day Lebanon) to acquire timber. A part of the account illustrates the use of oxen to drag timber to the shore after they have been felled:

“So the prince rejoiced, and he detailed three hundred men and three hundred oxen and assigned supervisors in charge of them to have them fell the timbers. They felled them, and they lay there throughout the winter, most probably to season the timber. In the third month of the third season they were hauled to the seashore, and the prince went out and attended to them” (*The Report of Wenamun*, 2,40-2.45).²⁹⁰

A later example is from the Justinianic period; during the construction of the timber roof of the catholicon of the St. Catherine’s Monastery at Mount Sinai, 13 intact wooden

²⁸⁸ Chetkova 1970, 78.

²⁸⁹ Simpson 2003, 116.

²⁹⁰ Simpson 2003, 121.

beams, each around 6 meters long, had to be imported to Egypt, possibly from Asia Minor, and moved up to the mountain.²⁹¹ It must also be noted that although these timbers were used in the catholicon of the monastery, the site itself was also a fortress on the Eastern frontier of the Empire, with a small garrison.²⁹² Considering the climate and the circumstances, the most logical beast of burden for such endeavor would be camels, perhaps two camels paired together.²⁹³ A depiction of a camel carrying wooden beams can be found on the mosaic floor of a 6th century Byzantine church from Petra (Figure 3).²⁹⁴ This mosaic, “camel carrying a tree trunk” is on Panel B14, and Waliszewski regards it as an “extremely realistic” depiction, and if the mosaic is accepted to be depending on Gazan influences, “the trunk of wood on the camel’s back may be a suggestion of *xylemporoi*, wood traders known from Gaza.”²⁹⁵

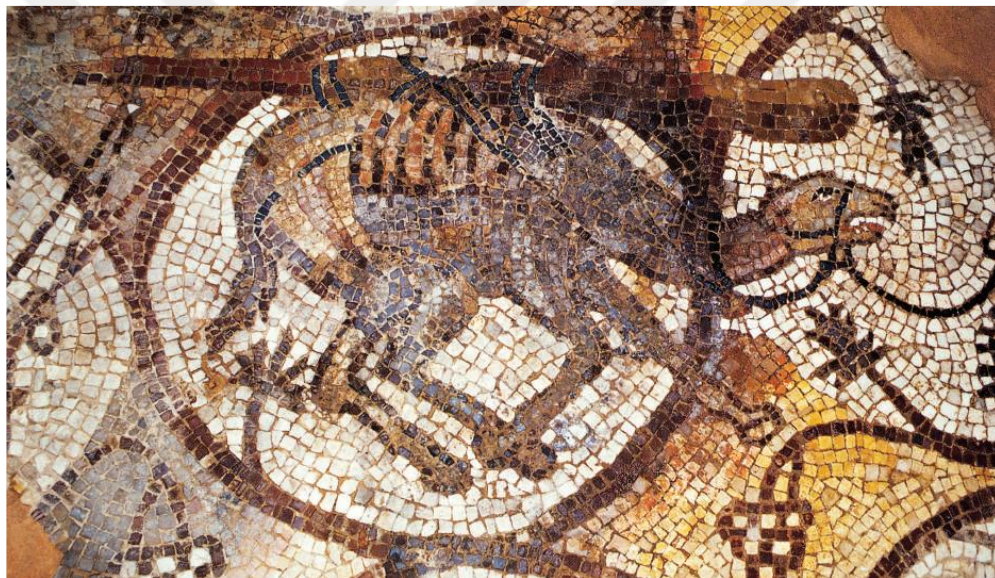


Figure 3 Petra Church Mosaic "Camel Carrying a Tree Trunk" (Fiema et al. 2001, 312.)

Another example of moving timber with animals -which has been previously mentioned- is from the Byzantine – Genoese War of 1348-9, Kantakouzenos decided to build a fleet at the Western end of the Golden Horn, at the arsenal of Kosmodion in order

²⁹¹ Forsyth 2016, 146.

²⁹² Forsyth 1968, 18.

²⁹³ Forsyth 2016, 146, n. 79.

²⁹⁴ Waliszewski 2001, 232.

²⁹⁵ Waliszewski 2001, 232.

to keep the construction away from the Genoese reach, could not ship timber by water because of the Genoese blockade of the Bosphorus. Thus, the Byzantines had to transport the timber overland from the Strandza mountains (Yıldız Dağları) on ox and mule carts (Kantak. IV.11, 5-15).²⁹⁶ However, this method is not attested frequently in the sources, which might indicate that it was not a common practice but was only resorted to if the transportation via bodies of water was not possible. Land transport is also evidently dependent on the climate of the regions, as in Petra the depiction is of a camel and around Constantinople, the use of oxen and mule is narrated. Similar practices were observed in the Ottoman period, the Council of Navy in 1851 undertook a General Probe (*istilamname-i umumi*) and in this document requested from local officials to inform if these forests were close to the rivers and the timber could be transported with rafts or boats, and to which sea the river flowed. Secondly, they wanted to be informed about the roads on which the timber could be carried and define the method of transporting the timber from the mountain: rolled down, by the river or pack animals.²⁹⁷ This document illustrates the similar transportation methods that were still in use during the Ottoman Period.

2.7 Timber Prices According to the *Edictum de Pretiis Rerum Venalium*

It can be expected that the logistical concerns that have been outlined would affect the prices of timber, and another variant in calculating the price of timber would be the type of tree that was to be bought. *Edictum de Pretiis Rerum Venalium*, or the “Edict Concerning the Sale Price of Goods”, was issued in 301 CE by Emperor Diocletian, and includes a section where different quantities and types of timber have been listed with their prices.²⁹⁸ The edict has been found in Latin and Greek fragments in various provinces of the empire, such as a well-preserved copy, inscribed in Latin on the facade of the Civil Basilica at Aphrodisias.²⁹⁹ It cannot be assumed that these prices were fixed for the Byzantine period, and Meiggs also notes that there are no other extensive records of prices that can be compared to Diocletian’s.³⁰⁰ It must also be remembered that these might not

²⁹⁶ This event is discussed in detail in Section 2.2.2. of this thesis.

²⁹⁷ BOA, A. MKT. NZD. 37/95.

²⁹⁸ Harris 2018, 223.

²⁹⁹ Erim and Reynolds 1973, 99.

³⁰⁰ Meiggs 1982, 367.

have been the “normal” prices, as the edict represents the maximum prices that could be charged per good, during a period of high inflation. Harris, on the other hand, argues that these prices were not “exorbitant.”³⁰¹ However, the section gives different tree types, and their prices can be compared with each other to see which timber types were assigned higher values. The prices in the Edict are given as length and the girth when the trunk has been squared, and the measurements have been given in units of *cubita* and *digiti*.³⁰² Meiggs have calculated the prices per square feet:

Table 2-1 Timber Prices from the Edict. After Meiggs 1982, 367.

Species	Length (ft.)	Girth when squared (ft.)	Price per sq. ft. (den.)
Fir/pine	75	6	295
Fir/pine	60	6	222
Fir/pine	45	6	80
Oak	21	5.6	6
Ash	21	4	12
Beech	21	3	21
Cypress	18	3	30
<i>Sappinus</i>	18	3	25

First of all, it must be pointed out that fir and pine are valued the same. It can be assumed that these are the maximum prices for the intact pieces of timber, since the price per square *cubitum* increases for fir and pine as the length increases. These intact, long pieces of timber can be assumed to have been used for shipbuilding and architectural construction. After fir and pine, cypress was the most expensive type of tree. It is followed by *Sappinus*, which Vitruvius defines either as a different species of fir or a lower part of the fir trunk which is of higher quality than the rest (Vitr. *De arch.* I. ii.8; XX. ix. 7). Beech, ash and oak, respectively, are the least expensive types of tree. This might be due

³⁰¹ Harris 2018, 223.

³⁰² One *digitus* was equal to c. 18.5 mm and one *cubitum* to c. 444 mm. See Smith 1851, 1024–30.

to the fact that these types of trees are more prevalent, and that they are lower quality. They are also presented in lower qualities, which might indicate that beech, ash and oak were not being used in large construction projects but were utilized for smaller items.



Chapter 3:

THE POLITICAL ECONOMY OF TIMBER IN BYZANTIUM

Woodlands were important natural resources and thus, states had the interest in controlling their exploitation. In the case of timber, it was not only needed for daily use in both urban and rural settings, but it was also a strategic material, utilized especially in the context of naval warfare. For this reason, the significance of timber for Byzantium increased particularly with the so-called disintegration of the Mediterranean after the Justinianic *reconquista* in the mid-6th century. Timber became a strategic resource in a larger political context of inter-state relations. In order to understand this development in the historical framework, the Byzantine control and exploitation of woodlands will be explained, and specific events related to timber politics in Byzantium will be surveyed in a diachronic perspective.

3.1 *State Ownership of the Woodland*

Hadrian's precautions regarding the protection of Lebanon's forests sheds light into how the state tried to claim authority over the forest resources. Thonemann notes that throughout antiquity and the Byzantine Middle Ages, large and potentially profitable stretches of woodland were normally regarded as state property.³⁰³ Hendy argues that in 7th century, around 15-18 % of the land belonged to the Byzantine state.³⁰⁴ Several sources reveal how woodlands were regulated and exploited by the state during the Byzantine period. In the Theodosian Code, a compilation and codification of Roman laws under Theodosius II in the 5th century, the state is shown to be a major owner of land, and the woodlands are deemed under the jurisdiction of the state. *Cod. Theod.* V.12.2 clearly states that if woodlands are included, no one is allowed to demand "patrimonial lands" and hold them as private property. The administration of these lands is given to "judges ordinary" (governors of the provinces) (*Cod. Theod.* V.14.31). Also, a rent was paid to the state for the exploitation of timber and firewood and for woodland-pasture on its domains (*Cod. Theod.* VII.7.2). This shows how the exploitation of timber sources was

³⁰³ Thonemann 2011, 280.

³⁰⁴ Hendy 1985, 637-38.

being controlled by the state and regulated in law during Late Antiquity. Dunn suggests that this practice would have carried into the Middle Byzantine period, stating that “much woodland in the ‘maritime provinces’ may in the Middle period have belonged to the state, as presumably did woodland and scrubland in regions reclaimed from Bulgar and South Slavic control, and in the Taurus and Antitaurus.”³⁰⁵ In addition to this, the *navicularii*, – private shipowners – were also supplied by the state with “materials for making suitable ships” which of course primarily implies timber (*Cod. Theod.* XIII.5.14).³⁰⁶ Also in the *Treatise on Strategy* (c. mid-6th century), it is related that the financial system was set up to “take care of matters of public importance that arise on occasion, such as the building of ships and of walls” (Anonymous, *Treatise on Strategy*, II.12.18–21). Evidently the state had control over these resources.

The assertion about the maritime provinces for example can be traced to the *De Cerimoniis Aulae Byzantinae*, written, or commissioned by Emperor Constantine VII (r. 913-959) in the 10th century. During the summary of the campaign against Crete in the 7th indiction (949 CE), there is a list of the administrative themes which sent ships to the expedition as well as the units that were left in the themes.

There was left as a guard for the City the *strategos* of the Aegean Sea with 6 *chelandia* that were *pamphyloi*, each with 120 men, and 4 *chelandia* with standard crew, each with 108 men, and also 1 unit³⁰⁷ was left behind for cutting timber for the eighth indiction (*De Cer.* II. 45. R664-65).

The *strategos* of the Kibyrrhaiotai with 6 *chelandia* that were *pamphyloi*, each with 150 men, and 6 *chelandia* with standard crews, each with 110 men; there were also left behind 2 *pamphyloi* and 4 [*chelandia*] with standard crews as a guard for the theme; there were also left behind 2 units for cutting timber for the 8th indiction (*De Cer.* II. 45. R665).

³⁰⁵ Dunn 1992, 273.

³⁰⁶ The *navicularii* were the landowners who were obliged to provide the state with ships and oversaw their construction, maintenance, and operation, in order to supply food (*fiscus*) to the population of the capitals and to the army. See Mor 2012, 48.

³⁰⁷ οὐσία: unit; either a crew or a ship and its crew. See Haldon 2000, 218 n.56.

It can be seen that about three units of man are left behind to fell timber for the next indiction, and since both the Aegean and *Kibyrrhaiotai* are maritime provinces, it is quite likely that this timber would be used for shipbuilding. This shows that the maritime themes had possibly their own arsenals or shipbuilding locations near wooded areas and were building their own ships instead of being supplied with ships by one main arsenal. Additionally, this material would also be necessary for the repairs and replacements in the ships that would (hopefully) make it back from the expeditions.

It is also appropriate that they are felling the timber for the next indiction and not for immediate construction as timber is often seasoned and dried before it is used in ship construction, as previously highlighted from Pliny's account (Plin. *HN*. XVI.74). Therefore, the timber required by the provincial fleets was at least in part cut by the crews, which, as already been pointed out, would have a shipwright as a part of it (Leo VI. *Taktika*. XIX.5). Since one crew would be left for each theme, it can be assumed that they were using the imperial or state-controlled forests of the specific themes. This also points to regional shipbuilding practices, and that when timber was available locally, it was exploited for shipbuilding, instead of being transported from long distances.

Imperial control of these lands seems to have been administered by forest wardens. The fiscal register (*praktikon*) of an imperial estate in the Western Anatolia belonging to the year 1073 mentions the *orophylax*; *oros* meaning woodland and therefore *orophylax* being the woodland warden.³⁰⁸ The same official position is also mentioned by Niketas Choniates in his *Historia*. Choniates criticizes Emperor Alexios for not taking any action against the Latin siege of Zara during the Fourth Crusade. The emperor was advised by his consultants to collect necessary war materials for a potential conflict against the Crusader army: weapons, engines and especially construction of war ships. However, he did not take this advice, and as Choniates relates, "Those who wanted to cut timber for ships were threatened with the gravest danger by the eunuchs who guarded the thickly wooded mountains, that were reserved for the imperial hunts, as if they were sacred groves, gardens, so to speak, planted by God" (Nik. Chon. 450). Instead of giving permission for the exploitation of timber, Alexios approved of the warden's behavior. (Nik. Chon. 451). It is of course Choniates' retelling of the events which might be biased

³⁰⁸ *Patmos* II, no.50 (1073) n. 123.124.126 in Nystazopoulou-Pelekidou 1980.

under the circumstances, but the emperors ban on felling of the timber shows the extent of the imperial authority the state had over these regions at the end of the Middle Byzantine period.

An important species in the context of state control over woodland exploitation is cedar. Cedar is a mountain tree that grows at high altitudes, and today occurs in Asia Minor, Syria, and Lebanon.³⁰⁹ Taurus cedar (*Cedrus libani*) can be found as high as an altitude 1100–3000 m above sea level and requires cool and moist winters with an annual precipitation of 1000 mm to 1500 mm, with warm and dry summers.³¹⁰ Cedar was emphasized in the ancient sources as a prime shipbuilding timber. Liphscitz, however, has demonstrated that cedar was widely used in the Bronze Age, but it is not found as a dominant timber in the original construction of any of the ships from the Byzantine Period.³¹¹

One reason for this might be the use of cedar wood for state-sponsored construction works, especially for the beams of churches. The basilica type church, which was the most common architectural plan for churches until late 6th century was essentially a “longitudinal assembly room, usually terminating in an apse and flanked by side aisles, all covered by timber trussed roofs, with the nave lit by clerestory windows in the upper walls”.³¹² These basilicas would require a timber roof of triangulated trusses, where the tie-beam would have been a single piece of timber, determined by -or determining- the length of the nave.³¹³ Although separate pieces could be used for the tie-beams, single pieces were preferred. Lev-Yadun also argues that in Israel, cedar wood was reserved for prestigious uses.³¹⁴ Procopius, who was the historian at Emperor Justinian’s (r. 527-528 CE) reign for example mentions the construction of a church in Jerusalem, where they:

“searched through all the woods and forests and every place where they had heard that very tall trees grew, and found a certain dense forest which produced cedars of extraordinary height, and by means of these they put the

³⁰⁹ Liphscitz 2012b, 94.

³¹⁰ Farjon 2017, 266.

³¹¹ Liphscitz 2012b, 94-8.

³¹² Ousterhout 2019, 13.

³¹³ Adam 2003, 428-9; Ulrich 2007, 138-50.

³¹⁴ Lev-Yadun 1992, 206.

roof upon the church, making its height in due proportion to the width and length of the building” (Procop. *Aed.* V.vi.15.).

In accordance with the boom of church construction during the Justinianic period, cedar, which grew tall enough to be used as a beam for specious naves might have therefore been reserved for church construction and thus is not present in shipbuilding.³¹⁵ When it is indeed observed in ships, it is found as Taurus cedar (*Cedrus libani*) in galleys, which were most probably constructed on the orders of the state or the navy, thus it is likely that cedar was controlled to some degree by the state.³¹⁶ In addition to this, the approximate period to return to timbering quality for cedar forests is more than 160-180 years without anthropogenic regeneration efforts.³¹⁷ Therefore once depleted, it would have been very difficult to attain cedar sources, which explains the possible state control over this valuable resource.

From a different perspective, Rich argues that during the “Medieval period” the quality of the ships that were constructed decreased, and the quantity increased. Cedar, on the other hand, grew in very high altitudes and logistically, lesser quality trees such as pine and cypress could substitute for cedar.³¹⁸ She argues that the Byzantine and Arab commissioners were not as “ambitious” as “the ancient pharaohs, kings and caesars”.³¹⁹ However, it must be noted that the Byzantine and Islamic ships were made with timber that did not require large scale logistical operations such as transporting cedar from high mountains, but their ships adapted to the socio-economic realities of the period, were durable and did their duty of transporting goods from one port to another. It can also be said that cedar was often reserved for different constructions, such as monumental architecture, than ships, or to certain types of ships.

³¹⁵ Treadgold 1997, 272.

³¹⁶ Akkemik 2014,

³¹⁷ Akkemik et al. 2012, 399.

³¹⁸ Rich 2016, 74.

³¹⁹ Rich 2016, 77.

3.2 *Woodland Exploitation and Timber Trade in Byzantium in a Chronological Perspective*

The imperial control over these regions are closely linked to the woodland's role as raw materials for fleets of the empire. In fact, the history of the timber use for shipbuilding in Byzantium relates to an analysis of domestic and foreign policymaking in the course of the empire. The state policy towards timber sources must have been for two reasons: firstly, to provide for their own fleet the necessary resources, and secondly, to prevent the adversary from gaining access to them. Sources that refer directly to shipbuilding timber are scarce; however, several anecdotes and passages from various sources can be used to draw a comprehensive picture of the political nature of timber trade.

3.2.1 *The Persian-Avar Siege of Constantinople*

After the end of the reign of Justinian in 565, timber would become a source of conflict between the Byzantines and both the Arabs and the Latins in the following centuries. After Justinian's reconquest, there were no large-scale naval conflicts recorded until the Persian War. Meanwhile, there were two naval encounters during the Persian-Avar siege of Constantinople in 626.³²⁰ Theophanes Confessor narrates that the Slavs "(...) filled the gulf of the Horn with an immense multitude, beyond all number, whom they had brought from the Danube in carved boats (*monoxyla*).” (Theop. *Chron.* AM 6117). A similar account of the same event is given in the Chronicle Paschale (*Chron. Pasch.* 723-725), although the encounter's narration is not as exaggerated as Theophanes' narration. Byzantines were victorious in both of the naval encounters, which were restricted to the vicinity of Golden Horn and the Bosphorus. The vessels that the Slavs have brought were dugout canoes and were not a match to the Byzantine forces. However, Theodore Syncellus records that after the Slavs were defeated, their *monoxyles* were collected from the sea so that they could be burned (Theod. *An. Av.* XXXIV). The ships and even their wood therefore were not reused or recycled, which could indicate that the Byzantines at this point were not in the need for timber in Constantinople. It might also be the case that this type of boat was not suitable for reuse as recycled timber and were

³²⁰ See Howard-Johnston 1995, 131-42 for the analysis of different accounts on the conflict.

just burned to avoid the enemy to take hold of them again, depriving the invaders of transport.

3.2.2 *The Islamic Navy*

The strategic aspect of timber has already been emphasized by referring to the imperial control over woodlands around the empire. Meanwhile, the crucial moment which increased the importance of timber as a strategic war material was the appearance of the Islamic Caliphate as a naval force in the Mediterranean. The Byzantines were defeated by the Rashidun Caliphate at the Battle of Yarmuk in 636, only a decade after the Persian-Avar Siege of Constantinople. The Caliphate then expanded to Syria, Palestine and finally captured Egypt in 640-42. Having spread around the Eastern Mediterranean shores, they started building a navy at al-Rawda Island (in Cairo) with which later went into action in 649 against Cyprus and Crete. Rhodes and Sicily were raided between 652-4.³²¹

However, Lombard suggests that the regions under the control of the Caliphate lacked the timber sources for shipbuilding.³²² Even in the conquered regions, the Christian control of timber can be seen. Ibn ‘Abd al-Hakam’s accounts that in al- Rawda, timber had to be obtained from “the Copts”, and the manager of finance, instead of taking it by force, paid a fair amount to buy the timber, possibly to avoid provocation.³²³ It is therefore not a coincidence that Phoenix in Lycia, which was rich in cypress trees “from which the masts of the ships were built,” was the location of the first major naval confrontation between the Arabs and the Byzantines.³²⁴ Dunn in fact sees the establishment of the maritime provinces as a part of the response to the Muslim presence in the Eastern Mediterranean.³²⁵ He supports that the tax burden of the inhabitants of these political organizations was geared towards supplying the needs of the fleet, these provinces had in their function “that of the strategic protection of the timber-resources of those regions against the Islamic states”.³²⁶

³²¹ Pryor and Jeffreys 2006, 25.

³²² Lombard 1959b, 236.

³²³ Torrey 1922, 90.

³²⁴ Fahmy 1966, 79.

³²⁵ Dunn 1992, 262.

³²⁶ Dunn 1992, 263.

Theophanes narrates that in the efforts to overwhelm the Byzantine naval forces Muawiyah appointed Abu 'l-Awar as the chief of shipbuilding for his expedition to Constantinople, which eventually led to the Battle of the Masts. The chronology of the battle is also not firmly established, however Cosentino proposes that the best hypothesis for the date of the Battle of the Masts is August 654, which would be in line with both Christian and Muslim chronology.³²⁷ There Emperor Constans II was with the Byzantine fleet (Theop. *Chron.* AM 6146). Theophanes also records that in his dream the emperor saw himself in Thessaloniki, and this was interpreted as a sign that the battle would be lost by him (in Greek “Thessaloniki” sounds similar to “give the victory to someone else”, *Θες αλλψ νίκην*). As a matter of fact, Constans II did lose the battle, and according to Theophanes, barely saved his own life. This anecdote is possibly Theophanes' exaggeration as the “the dream before battle” is a commonly-used trope in Byzantine literature. However, the fact that Theophanes decided to narrate as if Constans II went to battle despite the prediction that he would be losing it, might emphasize the importance of the region as a supplier of shipbuilding timber, especially in the conflict between the Byzantines and Arabs.

The date of the establishment of the Byzantine imperial navy, which would require regular supply of shipbuilding timber, is still contested amongst scholars. The Roman fleets were restructured after the Battle of Actium in 31 BCE by Augustus and permanent fleets were established at Misenum and Ravenna and provincial fleets spread around the Mediterranean.³²⁸ These fleets were mostly responsible for the protection of the *annona* fleet, patrolling against pirates, and the travel of state officials.³²⁹ Rankov emphasises that the Rhine fleet, *classis Germanica*, and the Danube fleets, *classis Pannonica* and *classis Moesiaca* were much more heavily engaged in fighting than the Mediterranean fleets of the time, which defended the northern borders of the empire against the Germanic incursions.³³⁰ Rhine and Danube were utilised not only to transport troops and supplies to the area, but they were also patrolling the rivers to prevent unauthorised crossings of the Germans.³³¹ Casson, however, proposes that when Diocletian was crowned emperor,

³²⁷ Cosentino 2007, 587.

³²⁸ Rankov 1995, 78; Casson 1994, 210.

³²⁹ Meijer 2014, 213-14.

³³⁰ Rankov 1995, 82. See Section 4.3.3 Yenikapı of this thesis for detailed information about the shipwrecks recovered from Mainz and Oberstimm.

³³¹ Meijer 2014, 215.

the provincial squadrons had vanished from the Mediterranean and the permanent fleets were drastically minimized.³³² However, it can be seen from the Battle of the Hellespont fought in 324 CE over 500 ships were put to sea, fleets possibly raised during the civil war.³³³ Again, The Gothic Wars were also amphibious attacks and thousands of soldiers and horses were transported to Africa and Italy in the 6th century.³³⁴ However, some scholars argue that the regular Byzantine fleet was only constructed when the Arab threat was present in the Mediterranean. Zuckerman for example proposes that there was basically no regular Byzantine fleet before the Battle of the Masts; instead, warships were constructed on demand and the creation of the regular fleet was a consequence of the creation of the Arab fleet, which he calls “learning from the enemy”.³³⁵ Cosentino, on the other hand, sees this as a development and expansion of the already existing navy as concurrent with the battle.³³⁶

The Arabs were raiding the shores from 7th to 9th centuries in order to acquire timber, among other motivations. Lombard suggest that Arabs often occupied regions in Southern Asia Minor, long enough (possibly wintering) to build ships there.³³⁷ Theophanes does mention Muawiya’s building of a big fleet, which is a claim also supported by Pseudo-Sebeos, a bishop writing the history of Armenia in the 7th century. Pseudo-Sebeos narrates that “He ordered 5,000 ships to be built, and he put in them [only] a few men for the sake of speed, 100 men for each ship, so that they might rapidly dart to and from over the waves of the sea around the very large ships.”³³⁸ By 670, Cyprus, Rhodes, Cos and Cyzicus were captured by the Arab forces.³³⁹ Another account refers to the year 673: Theophanes mentions Muslims wintering in Cilicia and Lycia, and when emperor Constantine IV learned about this he prepared two-banked (*bireme*) warships equipped with Greek fire siphons (Theop. *Chron.* AM 6164).

³³² Casson 1991, 240.

³³³ Pryor and Jeffreys 2006, 7.

³³⁴ Pryor and Jeffreys 2006, 13-4.

³³⁵ Zuckerman 2015, 69.

³³⁶ Cosentino 2007, 584.

³³⁷ Lombard 1959b, 243

³³⁸ Thomson 1999, 144-46.

³³⁹ Haldon 1990, 63.

What followed this is a very disputed event in the scholarship, the First Arab Siege of Constantinople lasting from 674 to 678. The only Byzantine account for the so-called siege is Theophanes Confessor who states that:

Every day there was a military engagement from morning until evening, between the *brachialion* of the Golden Gate and the *Kyklobion*, with thrust and counterthrust. Then, turning back, they went to *Kyzikos*, which they captured, and wintered there. And in the spring they set out and, in similar fashion, made war on sea against the Christians. (AM 6165)

As Mango and Scott note, this this does not seem like a continuous siege but a series of engagements.³⁴⁰ During this period, the Muslim navy would winter in Crete, *Kyzikos* or *Rhodes* in order to avoid bad weather, and assault the city during the summer. Haldon however uses the term “blockade” to describe the situation, which might better fit the nature of the conflict since it cut Constantinople’s connection to the Aegean in the summers.³⁴¹ Although the nature and dating of this conflict is open to debate, it is obvious that around the 670s both Arab and the Byzantine navies were operating in the region.

Thus, the 7th century witnessed intense shipbuilding activities from both sides, as the naval conflicts record ships that were sunk or burned by Greek fire, many of these had to be replaced. The Byzantine Empire was building the regular, imperial fleet, while the Caliphate was also constructing fleets in various arsenals. Fahmy, for example, records that the Byzantine Empire had maintained dockyards at *Alexandria* and *Clysma*, and these were taken over by the Caliphate after the conquest; shipbuilding activities continued with Greek and Coptic shipwrights.³⁴² The arsenal at *Clysma* was demanding caulkers, carpenters, wood and other fittings for ships from the village of *Aphrodito* in the 9th century.³⁴³ *Alexandria* became one of the most prominent warship construction sites of

³⁴⁰ Mango and Scott 1997, 494.

³⁴¹ Haldon 1990, 64. Howard Johnston recently proposed about the dating of this siege that Theophrastus is simply mistaken. He argues that Theophanes was influenced by the Arab propaganda that sought to glorify the naval aggression of the navy as the last years of Caliph Mu’awiya was filled with defeats to the Byzantines. (Howard-Johnston 2010, 303-4). Jankowiak has also proposed that “During the two years of his patriarchate, from 667 to 669, Constantinople was threatened by a powerful Arab army led by the son of the caliph” but not later than that, and the so-called first siege of Constantinople between 674-678 is an event that must be removed from the literature. Jankowiak 2013, 316. For his detailed analysis of the primary sources, see Jankowiak 2013, 237-320.

³⁴² Fahmy 1966, 23.

³⁴³ This is preserved in the *Aphrodito papyri* No. 1483, 1414, 1434 and 1449; cited in Fahmy 1966, 26.

the Caliphate.³⁴⁴ Rosetta, Damietta, and Tinnis were also naval centers, but Severus ibn al-Muqaffa, the Bishop of Hermopolis Magna, records that after a Byzantine attack, ships were ordered to be constructed at all coastal towns: “Consequently many ships were built and every year they repaired those which were damaged and built new ones in place of those which were wrecked.”³⁴⁵ There were many naval centers around the coast of Syria, most of the previously occupied cities, Acre, Tyre and Tripolis were also utilized by the Caliphate for shipbuilding and the departure point of several expeditions against the Byzantines.³⁴⁶ In southern Asia Minor, the main shipbuilding center was Tarsus, logically in close proximity to the timber sources.³⁴⁷

This heightened and ongoing naval conflict between the sides must have increased the use of timber resources in the naval construction activity compared to the earlier centuries in this case, of the Byzantine territories. At the end of the 7th century, Cyprus, which was rich in forest resources became a *condominium*, a territory of shared political sovereignty between the Umayyads (and later the Abbasids) and the Byzantines.³⁴⁸ However, the economic nature of this treaty of 686–88 is not clear, some have argued that the Arabs did not possess Cyprus but simply received taxes from it.³⁴⁹ Thus, it cannot be certain if the Arabs were able to exploit the forest resources of Cyprus during this period.

The early 8th century was a tumultuous period for the empire due to internal conflicts and various uprisings in the *themes*. At the same time, Maslama ibn ‘Abd al-Malik, the brother of the caliph, led an expedition to Galatia, which prompted Constantinople to prepare for a possible siege. Emperor Anastasios also sent a naval expedition to destroy the Muslims’ fleet and timber supplies in Lycia - “to burn their timber” as Theophanes puts it- where the “Saracens have sailed to cut cypress-wood” in the year 714-5. This expedition failed as the army of *Opsikion* revolted, instating Theodosius III to the throne (Theop. *Chron.* AM 6207). Following this, the Muslims laid siege to Constantinople, and the entrance of the Golden Horn was closed with a chain for the first recorded time. However, the siege was not successful, as the Byzantines were able to defend the city

³⁴⁴ Fahmy 1966, 28.

³⁴⁵ ‘Abd al-Masīh Burmester 1943, 13.

³⁴⁶ Fahmy 1966, 60-3.

³⁴⁷ Fahmy 1966, 52-3.

³⁴⁸ Zavagno 2017, 2.

³⁴⁹ Christides 2006, 44.

with Greek fire and the Muslim camps outside the city walls suffered due to the harsh winter cold and famine (Theop. *Chron.* AM 6209). Also, some of the reinforcement ships of the Muslims deserted, as they were manned with Egyptian Christian crews. The siege was abandoned in 718. This was followed by the dissolution of the *Karabisianoï* (the main fleet since the mid-7th century) and two new naval commands of an imperial fleet (*basilikon plomion*) and *Kibyrrhaiotai* were established.³⁵⁰ Pryor argues that the *Karabisianoï* either had performed poorly during the siege or had supported the deposed Anastasios II in a revolt against Leo III in 719.³⁵¹

The rest of the 8th century saw a consolidation of power of the Byzantine navy in the Mediterranean. The emperors of the ninth and tenth centuries, certainly from the reign of Leo V, at the time of the Caliphate's conquest of Crete, forbade the sale of timber to the Arabs.³⁵² In the 9th century, the Byzantine emperors were taking measures against strengthening the Arab forces. Leo V declared an embargo on all Byzantine trade with Egypt (Dölger no. 400). The exact date is not certain; however, it was sometime between July 813 and the Christmas of 820 according to McCormick.³⁵³ The reconquest of Cyprus, Crete and Sicily towards the end of the 10th century allowed the Byzantines to deny access to timber resources in these regions to the Caliphate. In 964, Byzantines asserted dominance in Cyprus, which was already a *condominium*, inhabited by a majority of Greeks compared to Arabs. However, Kaldellis argues that since this expedition prompted a counterattack by an Egyptian fleet (which was then annihilated by the Byzantines) the real motivation behind Nikephoros' undertaking was to deprive Egypt of access to timber for its fleets from Cyprus.³⁵⁴

3.2.3 Emperor John Tzimiskes and the Venetian Doge

The Byzantines did not only ban their own merchants from selling "war materials" (which presumably included timber) to the Arabs but they also pressured the Venetians

³⁵⁰ Haldon 1999, 77.

³⁵¹ Pryor and Jeffreys 2006, 32. Leo was the first iconoclast emperor who after a volcanic eruption in the Aegean Sea, took down the icon of Christ down from the Bronze Gate (Theop. *Chron.* AM 6218). This is of course condemned by Theophanes in his narration as he was an iconophile, but this decision by Leo II can also be taken as a precaution, induced by the losses against the Muslims.

³⁵² Dunn 1992, 263.

³⁵³ McCormick 2001, 899.

³⁵⁴ Kaldellis 2017, 47.

to cease the trade of war materials. A decree dating to July 971 is evidence of the Byzantine Emperor demanding from the Venetians not to send timber to Egypt.³⁵⁵ The decree was announced in Rialto, during the reign of John Tzimiskes, and the Venetians who were at that time still under partial Byzantine rule were told by the envoys not to send lumber and weapons which their ships were carrying to Saracen territory.

Whereas earlier in the aforesaid indiction imperial envoys were dispatched to us by John [I], Basil [II], and Constantine [VIII], most sacred emperors, to inquire about the lumber and weapons which our ships were carrying to Saracen territory, and to make terrible threats by order of the most glorious emperor—that if [the Venetians] should lend assistance to the barbarians with this lumber, [an act] which would be [against] the dignity of the empire and [against] the Christian people, they would have [all] the ships they found set afire together with the men and the cargo.³⁵⁶

Therefore, Doge Pietro Candian IV decreed that armor and weapons would not be sold or gifted to the Saracens. When it comes to the lumber, it is specified that the Venetians would not carry “elms, maples, broad planks, oars, spars, or other lumber that may cause harm to Christians that could be used in shipbuilding.” Meanwhile, exemptions are made for “trimmed logs of ash five feet long and one ax wide, and vases, bowls, and cups, and tree planks likewise five or six feet long”; therefore, articles of regular trade were still allowed. It is also mentioned that after the ships would leave Venice, they would not be taking aboard lumber from other ports, in case it could also be sold to the “barbarians.” Jacoby notes that this was a reference to the Dalmatian coast, where the Venetians had gradually consolidated their power and navigation safety up to the 10th century, and possibly even Asia Minor.³⁵⁷ The punishment was a hundred pounds of pure gold, or in the case of not paying this, capital punishment. It is mentioned in the decree that it would be “in full force forever”; however, Doge Pietro Candian IV was murdered by a mob five years after, which may have ended the enforcement, if it ever was applied.

³⁵⁵ Decretum, July 971: Venedig, no. 14, pp. 26–30, cited in Lopez and Raymond 2001, 333–35.

³⁵⁶ Decretum, July 971: Venedig, no. 14, pp. 26–30, cited in Lopez and Raymond 2001, 333.

³⁵⁷ Jacoby 2004, 374; 382.

Even if this decree was not enforced, it still shows the measures the Byzantines were taking against the armament and shipbuilding activities of the Muslims. This might also be connected to the military achievements of John I Tzimiskes, as he expanded the borders of the empire during his reign, both in the Balkans against the Kieven-Rus and against the Abbasid Empire. This political power he acquired might have encouraged him to strengthen his position in the West against the Venetians at the same time controlling the flow of war materials to especially the Muslims.³⁵⁸ It also implies that the Venetians supplied a considerable amount of timber to Egypt. This is evident from the end of the decree as well: three ships are mentioned which were about to sail with the cargo of lumber before the Byzantine envoy reached Venice. Two of them were sailing to Mahdia (Tunisia) and one to Tripoli (Libya), and those were given permission to carry logs and spars.³⁵⁹ The grounds that these men were allowed to sail is in fact that they were found to be “poor”, which might point to a lack of interest in enforcing such edicts on the part of Venetian authorities.

3.2.4 *Restrictions on Mount Athos*

The monasteries were also one of the suppliers of timber in Byzantium. It is important to mention several restrictions of the monastic establishments’ role in the trade of timber in the context of the political restrictions on the monastery’s activities in internal trade. It can also be seen that although the first reference to this is from the 10th century, the restrictions increase in time.

The first one is the *typikon* of Emperor John Tzimiskes dating to 971–72 from the Athonite Monasteries:

[24.] Regarding firewood which has been cut on the Mountain by the monks, we desire that it not be transported and sold outside, but that it be sold on the Mountain. In an emergency, though, let it be sold to laymen.³⁶⁰

³⁵⁸ Kaldellis 2017, 71.

³⁵⁹ Decretum, July 971: Venedig, no. 14, pp. 26–30 cited in Lopez and Raymond 2001, 334.

³⁶⁰ Thomas et al. 2000, 240.

The *typikon* of John I Tzimiskes documents that he forbade the traffic of firewood from Mount Athos in 972, a year after the Venetian decree.³⁶¹ Dunn suggests that firewood is often the by-product of timber felling and logging, which was evidently being practiced at Mount Athos.³⁶² Even though this regulation is more concerned with commercial activities of the monks, it might still be the result of John I's attempts at consolidating power against the monastic establishments. This is followed by the *typikon* of Emperor Constantine IX Monomachos in 1045, expanding the ban:

(6) Concerning this matter, however, certain ones raised the issue that some monks were exporting by boat lumber for building, thin planks, firewood, and pitch outside the Mountain and were selling these commodities to men of the world, and moreover, they suggested that such activity had been banned by the ancient *typikon*. Thereupon, we laid down that hereafter no one ought to do such a thing but should sell these items to those on the Mountain for the private needs of the monasteries themselves. If, however, anyone is caught in such activity, he shall suffer the loss of the boat itself in a manner we have mentioned above.³⁶³

This suggests first that the monastic communities were also trading timber, and secondly that the emperors had the power to curb this trade in order to protect the interest of the state. Especially after the Arab conquest of Crete, measures were taken to prevent the Arabs from acquiring timber that was necessary for their fleets. Dunn suggest that Constantine IX's insertion of a general ban on the sale of timber, boards, and pitch, by the monasteries of Mount Athos into the *Typikon* of 1045 was an effort towards decreasing the traffic of wood both in and outside of the empire and direct it towards the needs of the state.³⁶⁴ The regulation concerning Constantine IX was established two years after the Rus-Byzantine war of 1043. Michael Psellus narrates that since the fleet was lost to the fire three years before the war, the ships were scattered and the navy was below its strength (Michael Psellus *Chronographia* VI, 93). Although the Rus were defeated, the

³⁶¹ Thomas et al. 2000, 240.

³⁶² Dunn 1992, 259.

³⁶³ Thomas et al. 2000, 287.

³⁶⁴ Dunn 1992, 263.

need for a regular fleet was apparent, and this might be connected to Constantine IX's measures concerning the trade of timber.

Another restriction related to a possible scarcity within the empire itself might be observed from the two chrysobulls in the *Rule* of Michael Attaleiates for his Almshouse in Rhaideustos and for the Monastery of Christ *Panoiktirmon* in Constantinople from Emperor Michael VII Doukas (1075) and Nikephoros III Botaneiates (1079).³⁶⁵ Both of these chrysobulls prevent the “the cutting and transport of any sort of wood or the transport of oars, or anything else”.³⁶⁶ Oars especially are used in galleys, whose construction was under state monopoly. Thus, this specific restriction might also be related to the monasteries being involved in the trade of timber in the form of war materials or the need of the state of these resources itself. In the light of these restrictions from the 11th century, however, it can be safely assumed that the monasteries were involved in the timber trade within the empire, which have been recorded to be restricted by the state in various occasions.

3.2.5 *Further Restrictions on Timber Trade*

The restrictions of trade were not always for the trade of timber but did also affect its exchange. Before Constantine IX Monomachos' reign, the Basil II had banned trading and travel to Muslim countries. This was described by Yahya of Antioch, who himself lived amid the Byzantine-Muslim conflict of the early 11th century (Yahya of Antioch III: 401– 403). This ban was a significant blow to the prosperity of the Muslim rulers in the region and was instated not for economic concerns, but political ones. Basil -who was at the time in the Balkans campaigning against the Bulgars- restricted travel and trade between the empire and Syria and Egypt, excepting only his allies Salih ibn Mirdas and the tribe of Kilab from this embargo. This was a move to influence the outcome of the Muslim internal conflict of the period in Aleppo. Jacoby also mentions an instance around 1174, when Byzantines confiscated a Genoese ship that was carrying 1332 oars, 120

³⁶⁵ Thomas et al. 2000, 262, 266.

³⁶⁶ Thomas et al. 2000, 262, 266.

beams and large planks and small wooden logs.³⁶⁷ He suggests that the Genoese had purchased these from southern Asia Minor and were transporting to Egypt.³⁶⁸

3.2.6 *The End of the Byzantine Navy*

The consolidation of Byzantine power in the 10th and 11th centuries did not last into the 12th century. The battle of Manzikert (1071) followed by Myriokephalon (1176) a century later resulted in massive loss of territory in Asia Minor. Niketas Choniates relates that it was John of Poutze, the *logistes megistos* (general superintendent of revenue collection), who persuaded Emperor John II Komnenos (r. 1118 – 1143) to cut down the funds of the navy, arguing that:

(...) the state and public did not always have need of the *triremes* and that the expenditures made on their behalf were a heavy annual burden, and that these funds, therefore, should be deposited in the treasury and that supplies and pay should be provided the navy by the imperial treasury only when needed. (Nik. Chon. 33).

However, a large fleet was mobilized against the Norman attack on the Ionian and Aegean in 1147, but Pryor argues that the numbers given by Niketas Choniates (1.000 *trireis*) were exaggerations.³⁶⁹ The fleet however was in a steady decline. Michael Stryphnos, for example, who became the *megas doux* under Alexios III (r. 1195 – 1203) sold the fleets anchors, sails and other gears for his own personal benefit.³⁷⁰

The catastrophe which ended the Middle Byzantine period was the Fourth Crusade of 1204 and the capture of Constantinople by the Latins. The capital of the Byzantine Empire was lost for almost sixty years, until its recapture by Michael VIII in 1261. Michael VIII was another Byzantine Emperor who had to make strategic diplomatic maneuvers to balance the now weakened empire against the Latins. A crucial point was the naval battle of Settepozzi in 1263, where the Byzantines were allied with the Genoese against the Venetians. The hesitation of some of the Genoese admirals resulted in the loss

³⁶⁷ Jacoby 2001, 109.

³⁶⁸ Jacoby 2001, 109.

³⁶⁹ Pryor and Jeffreys 2006, 113.

³⁷⁰ Brand 1991, 1968.

of the battle.³⁷¹ After this, Michael VIII changed his diplomatic policy and expelled the Genoese from Constantinople, opening negotiations with the Venetians. A Greco-Venetian treaty was signed in 1277 (which in fact was not presented as a treaty, but as a chrysobull) and Michael VIII granted Venetians permission to buy rudders, masts, timber and in general everything useful for their ships.³⁷² Nicol points out that this treaty was only for two years.³⁷³ It can be seen that timber as a war material was still a strategic resource in Byzantine diplomacy; however, instead of restraining other sea powers from acquiring it from the Byzantine lands, in this instance it was used as an incentive.

The navy was disbanded by Emperor Andronikos II in the late 13th century as an economic measure, who thought that the navy was a too large an expenditure on the budget and that Genoese ships were enough to defend the empire.³⁷⁴ The last recorded expedition of the Byzantine navy was the deployment of 80 ships to support an army that had invaded Thessaly in 1283. At this point, the timber supply for shipbuilding then was directed to merchant ships and exports. Meanwhile, the earlier sources of timber – southern Asia Minor and most of the Black Sea coast – was already lost to the Byzantines. There is scattered evidence for timber export in later periods; for example, in 1278, Venetians were exporting timber from Thessalonica when they were intercepted by Greek pirates.³⁷⁵ Yet there are no other texts from this period explicitly discussing timber export from the Byzantine Empire.

3.2.7 *Limits of State Regulation of Timber Movement*

So far, the focus has been on the exchange that was controlled (or at least intended to be controlled) by the state. This is in line with Lombard's argument on the trade between Byzantium and the Caliphate for example, he argues that trade was conducted only in the terms of tight regulations governed by treaties and was oriented towards feeding the capitals.³⁷⁶ However as recent research shows, trade between Byzantium and the caliphate especially after 10th century did not only flourish, but was also not always

³⁷¹ Geanakoplos 1959, 161.

³⁷² Miklosich and Müller 2012, 91.

³⁷³ Nicol 1988, 197–201.

³⁷⁴ Nicol 1993, 108.

³⁷⁵ Tafel and Thomas 1856, 278.

³⁷⁶ Lombard 1959b, 226–27.

controlled by the states. Exchanges were in very different forms, Jacoby points to dowries and gift-giving as one mode of commodity exchange.³⁷⁷ Cutler for example looks at gift giving as an incentive for production and further exchange of goods between Greeks and Muslims.³⁷⁸ At the same time, pirates from both sides were operating in the eastern Mediterranean coasts.³⁷⁹ Ibn Hawqal, for example, complains about 10th century Muslim rulers letting “the Byzantines to send their ships to Muslim ports for trade and their agents to travel in their countries” which would enable the Byzantines gather information about Muslim territories.³⁸⁰ Muslim merchants were recorded to be in Constantinople as early as 9th century.³⁸¹ This connectivity is also attested in the archaeological record. Regarding long distance trade between the Muslim and Byzantine territories, Serçe Limani shipwreck which has been dated to c. 1025 is an important example. It was most probably a Byzantine merchant ship, returning from Fatimid Syria to the Marmara Sea region with a cargo that included Fatimid glass.³⁸² Thus, the exchange between the Byzantines and Muslims, regardless of state restriction or incentive continued in different means and scales.

This was especially the case for the frontier regions, such as the Syrian-facing Cilician frontier as one of the major passages between the Byzantine and Islamic worlds in the 9th and 10th centuries.³⁸³ Durak has demonstrated that not only the land routes but also the Mediterranean coastal route which connected Cilicia to Attaleia was moving trade goods.³⁸⁴ This was not only the case in peaceful periods, but local trade also continued during wartime across the frontier between Byzantium and the Caliphate.³⁸⁵ In addition, as Eger points out, trade was not the only medium of exchange; smuggling, tribute and gift exchange was also actively performed across the frontier.³⁸⁶ He also points

³⁷⁷ Jacoby 1998.

³⁷⁸ Cutler 2001.

³⁷⁹ Jacoby 1998, 91.

³⁸⁰ Jacoby 2017, 639.

³⁸¹ Reinert 1998, 130-31.

³⁸² van Doorninck 2002, 137.

³⁸³ Durak 2013, 141.

³⁸⁴ Durak 2018, 172.

³⁸⁵ Durak 2018, 176.

³⁸⁶ Eger 2015, 287.

out that the access to Taurus Mountain forests influenced certain interactions between Islam and Byzantium, whether peaceful or belligerent.³⁸⁷

One of these interactions has been documented by al-Bīrūnī, an Iranian scholar writing in tenth and eleventh centuries. In his *Book on the Pharmacopoeia of Medicine* (*Kitāb al-ṣaydanat fī al-ṭibb*) he writes:

In the mountains of al-Rum there is a tree called the shars/sharsh tree, and it is one hundred cubits tall. It is equal to teak in its firmness and it flows on water. Boats are made from it. The abdal [Sufi saints/devotees] of Tarsos cause these trees to fall and transport them towards the coast during peaceful times [during the times of truce with the Byzantines]. They push them [the logs] into the sea on wooden beams and carry them on earth towards the sea.³⁸⁸

Durak argues that the “Roman” mountains in question here are Taurus Mountains west and/or north of the Cilician plain.³⁸⁹ Therefore, when there was peace, the Muslims who at that point controlled the Cilician plain would enter the Byzantine territory, or their own territory which became safe enough for these activities and fell trees, to be transported to the coast (probably with log rafts on the river from the description). Durak suggests that the destination might have been Syria or Egypt, where timber was as mentioned, scarce.³⁹⁰

Another point of connection has been identified by Eger as Ḥiṣn al-Tīnāt, located near the Syrian Gates in the Amanus Mountains, connecting Anatolia (via Cilicia) with Syria (via the Amuq Plain).³⁹¹ Eger argues that this port site functioned both as a military *thaghr*, or frontier post, and a seaport that exported timber.³⁹² After several seasons of land surveys, Eger concludes that the settlement which he identifies as Ḥiṣn al-Tīnāt did not proceed a Roman or Byzantine city but was moved from a Roman site to its particular location during the Early Islamic phase. Eger argues that the reason of this relocation was

³⁸⁷ Eger 2015, 282.

³⁸⁸ al-Bīrūnī, *Kitāb al-ṣaydanat fī al-ṭibb*, 327, quoted in Durak 2018, 177.

³⁸⁹ Durak 2018, 177.

³⁹⁰ Durak 2018, 178.

³⁹¹ Eger 2010, 49.

³⁹² Eger 2010, 49.

the changing courses of river, which was crucial in moving timber from the Amanus Mountains to the coast.³⁹³ Ibn Hawqal wrote in mid - 10th century:

Also al-Tinat was a fortress (*ḥiṣn*) on the coast which has a cutting place (*maqṭa'*) [or depot {*majm'a*} according to Istakhri] for pine wood (*khashab al- ṣanawbar*) which was exported (*yunqal*) in large quantities (*mā lā yuḥṣā*) to Syria, Egypt, and the frontier (*al thughūr*), and also in it were strong warriors (*rijāl quttāl ājlād*), who had knowledge of how to harm (*maḍārr*) the Byzantine Empire, and knew well its fords (*makhā'id*) and dangerous places (*mahālaka*).³⁹⁴

Ibn Hawqal's narration points to a more hostile interaction along the frontier, however, demonstrates clearly that the fortress of al-Tīnāt was one of the gateways where timber was transferred to Syria and Egypt. Thus, although the Byzantine Empire attempted at controlling the timber flow from southern Anatolian coasts, the frontier settlements and fortresses were used to secure the movement of this material to the scarcely wooded areas of the Muslim rule.

3.2.8 Conclusion

It is not logical to assume that a shipwright during the Byzantine period, especially outside Constantinople necessarily had access to the writings of the ancient authors like Theophrastus or Pliny; as shipbuilding was a profession where the knowledge was transmitted mostly orally. However, these texts could demonstrate the traditions or practices that the authors had observed. At the same time, it can be seen how crucial timber for shipbuilding was, since many forested regions were controlled by the state during most of the span of the empire, and any obstruction to these resources would be a political problem. Although the Byzantine – Arab rivalry was not structured only around access to ship timber sources, it was affected by the severity of the need of both the naval fleets and the merchants. This conflict later included the emerging Latins from the West.

³⁹³ Eger 2010, 72.

³⁹⁴ Ibn Hawqal 1967: 173; translated and quoted in Eger 2010, 51.

Venetian, Genoese, Pisans and Amalfitans traded with both sides in shipbuilding materials including timber, iron and also other armaments.³⁹⁵

Timber trade was an essential part of economy, and the demand for ship construction materials was not only a matter of maritime trade but also security. The use of timber for warships made it a strategic commodity, and for this reason the Byzantine state tried to both control the exploitation of wooded regions and also the trade of timber. The trade restrictions did not only apply for the production in Byzantium but allowing or restricting the trade of timber was also used as a diplomatic tool in negotiations with the Latins. However as recent research suggests, while state regulations might have been a large-scale strategy, it did not apply to all regions of the empire, especially the well-wooded frontier regions of Cilicia. The references to the Arabs' procurement of timber and the Latin trade with the Muslims show that such embargoes would be hard to enforce at the edges of the empire, especially if local elites on the Byzantine side were profiting from this trade. It is, however, important to emphasize the interests and efforts of the state regarding the timber trade, and the political and economic role of timber.

³⁹⁵ See Jacoby 2001.

Chapter 4:

SHIPWRECKS AND ARCHAEOLOGICAL EVIDENCE

This chapter will discuss 45 shipwrecks dating between 4th and 11th centuries, to draw a broad picture of timber use for shipbuilding in the Eastern Mediterranean. It will also refer to earlier shipwrecks in the context of continuities and changes in wood use for shipbuilding. This analysis will be both regional (the Levant, Mediterranean and Aegean coasts of Asia Minor and the Marmara Sea) and chronological, as well as incorporating the different choices for three main parts of wooden ships: the hull planking, frames, and keel (Figure 4). Some shipwrecks will be examined individually and for some assemblages, a general overview will be given with specific examples. The aim is to understand the shipwreck evidence of timber supply for shipbuilding; to spot if there indeed are any changes in the wood type in a chronological perspective, to see if certain trees were preferred for different parts of the ship or different types of ships, and if regional trends have developed.

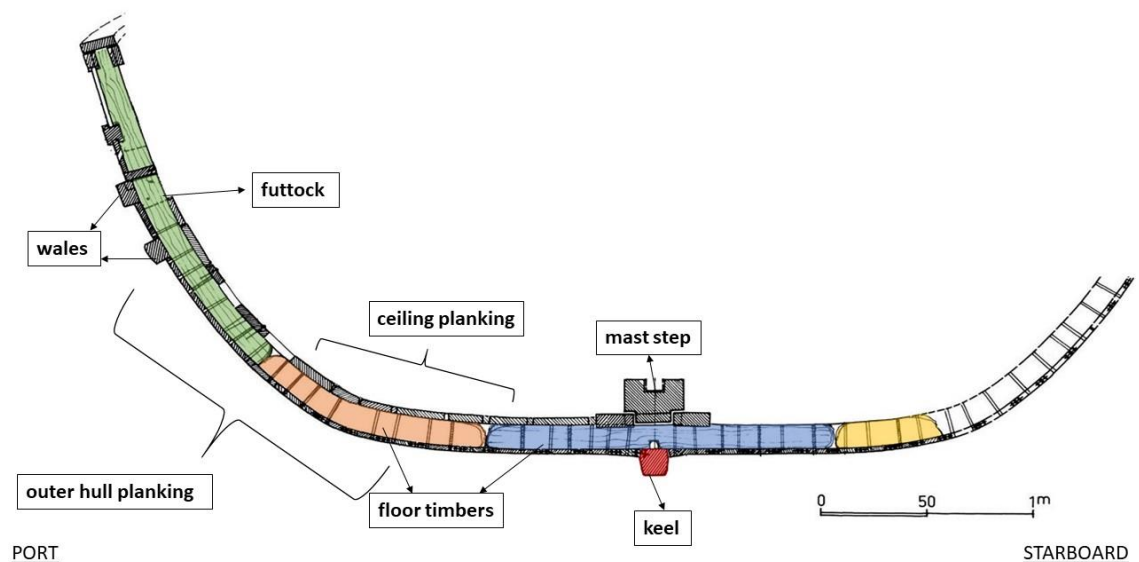


Figure 4 Ship parts labeled on the cross section of L'épave 2 de l'anse des Laurons, 2nd century CE shipwreck. (Adapted from Gassend et al. 1984, 94.)

4.1 *The Nature of the Evidence*

There are several drawbacks due to the nature of the evidence when the study of the wood type is concerned. One very obvious problem is the mobility of the ships. As Basch put it, “The most important limitation [of nautical archaeology] is the virtual impossibility of deducing the shipyard where a vessel was built.”³⁹⁶ Shipwrecks are found wherever they were sunk or abandoned. This location on its own gives us no information regarding the location of its construction. In addition to this very basic consideration, other factors make it difficult to analyze the evidence at hand.

4.1.1 *Long distance Timber Movement*

Not only ships are mobile, but long distance movement of timber has also been attested in both textual and archaeological evidence very frequently in the Mediterranean. It is highly unlikely to recover a shipwreck that would directly demonstrate this movement of timber as cargo, since such cargo would have in most cases decayed underwater and left no trace. Shipwrecks with cargoes of other building materials such as stone, however, have been found on many occasions around the Mediterranean. Russell, for example, identifies eighty-two shipwrecks from the Roman period with stone cargoes.³⁹⁷ Long distance timber movement, especially with the intact pieces desired for construction works or shipbuilding, might have had similar logistical concerns and difficulties with stone trade (especially for loading at the docks); the material had to be carried from the extraction area down to a body of water for transport, loaded and unloaded at harbor facilities equipped with cranes to lift the heavy weights.³⁹⁸ Thus the shipwrecks with stone cargoes show that logistically, the long distance shipment of timber by sea was not only possible, but was routine as the necessary infrastructure existed. Dockside cranes have also been depicted in Roman art.³⁹⁹ As a later example, documentary evidence from 18th century during the Ottoman period demonstrates that timber from the imperial storage in Istanbul were shipped to Alexandria to be used for

³⁹⁶ Basch 1972, 50.

³⁹⁷ Russell 2014, 116.

³⁹⁸ Russell 2014, 137.

³⁹⁹ Casson 1976, 345; Coetlogon Williams 1976, 77.

shipbuilding on merchant ships rented by the state.⁴⁰⁰ There is also evidence of a crane that was used to lift these timbers at the Alexandrian harbor during this period.⁴⁰¹

There are several sources from the Roman period that illustrate the long distance movement of timber. Meiggs for example, argues that during the early imperial period, the city of Rome saw a population increase, which also increased demand for wood in two main areas; as charcoal for fuel and for construction works.⁴⁰² Most of this was supplied by sea; in fact, it may have been the increase in the use of sea-borne timber that led to some merchants specializing in shipping timber. The earliest evidence so far of the *navicularii lignarii* (traders of wood) is the inscription from the Piazza delle Corporazioni in Ostia, near the ancient port of Rome, which Meiggs dates to 2nd century CE (Inscription CIL XIV 4549, 3).⁴⁰³ Terpstra suggests that the wood in question might have been both for construction works and also to supply the imperial baths with fuel.⁴⁰⁴

Another important example of long distance trade is from 1st century CE. Vitruvius in the 1st century BCE wrote that “Different things are found in different places, the transport of them may be difficult and costly” (Vitr. 1.2.8). His suggestion in this case was to substitute these with cheaper alternatives, “the need for fir or *sappinus* will be met by using cypress, poplar, elm, or pine” (Vitr. 1.2.8). Meiggs also argues that Romans might have used chestnut when pine and fir was scarce as an alternative to oak as chestnut grew in greater lengths.⁴⁰⁵ But Vitruvius also mentions that larch wood, which was found in the Alps was fire resistant, and if it was transported to the city of Rome, it could solve the problem of fires spreading in the city. (Vitr. 2. 9. 16). Vitruvius’ advice was in fact realized after a century. Pliny mentions that, Emperor Tiberius (14 – 37 CE) brought larch from Raetia (modern day Switzerland) for a reconstruction project after a fire, which would point to a long distance transportation of this tree, evidently not impossible when under imperial commission (Plin. *HN*. XVI.lxxvi.202). Therefore, whereas alternatives

⁴⁰⁰ Mikhail 2017, 159.

⁴⁰¹ Mikhail 2017, 159.

⁴⁰² Meiggs 1980, 187.

⁴⁰³ Meiggs 1980, 190.

⁴⁰⁴ Terpstra 2013, 107.

⁴⁰⁵ Meiggs 1980, 188.

existed, the desirability of certain wood species would have incentivized long distance trade.

It is also possible to observe timber arriving to the city of Rome from long distances in the archaeological record. At an excavation carried out during a metro line construction in Rome, timbers belonging to the foundations of a patrician villa were unearthed which were felled between 40 and 60 CE.⁴⁰⁶ Dendrochronological analysis showed that the trees (*Quercus* sp.) were around 300 years old oak when they were felled, and were provenanced to north-eastern France, possibly transported from the Jura Mountains.⁴⁰⁷ It has been argued that the timbers were rafted and floated through the rivers in Gaul –the Saône and Rhône rivers– and eventually shipped by sea and up the Tiber River to Rome.⁴⁰⁸ This shows that oak which grew as far as the French Alps were transported to Rome as construction material.

Another example that illustrates that long-distance timber movement was not a practice specific to the city of Rome is from a Roman harbor in Forum Hadriani (Voorburg in modern day Netherlands). Oak piles were found during the 2007–2008 excavation campaign, which showed two distinct construction phases, one dating to 150 CE, and the second to 205 CE.⁴⁰⁹ The first phase shows a variety of origins for the construction timber, which could indicate the stockpiling of the logs at a distribution center, from which the wood was sent to construction sites.⁴¹⁰ In the second phase, all of the wood was coming from a single source, the central part of Germany and/or the Mosel area, pointing to the transport through the rivers of Mosel and Rhine. The age of the trees at the date of felling was around 300 years, probably indicates the exploitation of a forested area “where logging activities had not had a strong impact on the forest yet.”⁴¹¹ The evidence shows that Rome, especially during the imperial period had a strong network of timber supply, not only for the capital, but also to the frontier regions. The Rhine-Meuse frontier zone in Northwestern Europe was dotted with small forts, and wood was often the dominant material used in their construction, such as defensive ditches and

⁴⁰⁶ Bernabei et al. 2019, 6.

⁴⁰⁷ Bernabei et al. 2019, 6.

⁴⁰⁸ Bernabei et al. 2019, 11.

⁴⁰⁹ Domínguez-Delmás et al. 2014, 651.

⁴¹⁰ Domínguez-Delmás et al. 2014, 651.

⁴¹¹ Domínguez-Delmás et al. 2014, 652.

ever wooden water pipes.⁴¹² Similar practices could be applied to the Eastern Roman Empire, and the city of Constantinople. As it was mentioned in the Theodosian Code, “African shipmasters who convey wood suitable for public uses and needs” were given privileges (*Cod. Theod.* XIII. 5. 10). This law in fact renews the earlier privileges, showing that long distance supply of timber continued. The archaeological evidence for the use of timber transported from the Black Sea woodlands in Constantinople is also discussed in this chapter.

It has already been shown that for several parts of a ship, namely the keels, masts, and hull planking, as well as wales and stringers, longer timber pieces were needed. Meiggs argues that the specific demand for pine and fir (which would be suitable for this) might have led the shipbuilders to acquire the timber from long distances, “provided that the prices were competitive.”⁴¹³ If the price of good quality imported timber for shipbuilding was relatively low compared to the local sources, the timber could have been imported from long distances using the infrastructure and technology of the time. Thus, the location of the ships sinking is not necessarily where the ship originated from, and where the shipyard was located is not necessarily where the timber came from.⁴¹⁴

Meanwhile, local timber was more likely used for smaller vessels intended for short-distance use. For example, the two small vessels found in the ancient harbor of Pisa indicate the exploitation of local timber sources. The vessels both date to 1st – 2nd centuries CE, Ship “F” was constructed with hardwood, namely oak (*Quercus*) and ship “C” was constructed with softwood, maritime pine (*Pinus pinaster*). Pollen cores were collected from areas next to the ships and the layers were of the same epoch of the two shipwrecks.⁴¹⁵ The analysis shows that the material that was used in both shipwrecks could be found locally during the period of their construction.⁴¹⁶ Although these are common species, the finds are consistent with a local origin. The difference in the type of wood that was used, however, most probably depended both on the intended use of the

⁴¹² Loveluck 2013, 215. Several wooden structures such as wooden water pipes from the Roman period were only attested in Northern Europe and Britain, Ulrich 2007, 88.

⁴¹³ Meiggs 1980, 190.

⁴¹⁴ Kuniholm et al. 2007, 383-84.

⁴¹⁵ Giachi et al. 2003, 270.

⁴¹⁶ Giachi et al. 2003, 282.

ships, and the wood available at the time. Ship C was made with a softwood, which could be lighter and thus more suitable for sea navigation. Meanwhile the 8.18 m, flat-bottomed “Ship F” (which later was called Boat F) has been identified as a river boat, explaining the use of durable but cheaper oak (illustrated in the Diocletian’s Price Edict) as the boat was intended to be used for carrying cargo in the river.⁴¹⁷ A similar conclusion was also made for the shipwreck Napoli C, a small harbor service boat dating to 1st – 2nd century CE from Naples, Italy.⁴¹⁸ All timber types used in the shipwreck are present in pollen spectra, and it was argued that since it was a small ship for harbor service unsuitable for long distance transportation, it is more likely that it was built of local timber.⁴¹⁹

From these accounts of timber trade, it can be seen that it depended on not only local availability, but also logistical networks. When the abovementioned examples are analyzed, it can be inferred that it was often the state that initiated the long distance trade of timber. Although this does not always appear to have to be the case, unless an investment from an entity with considerable economic power, such as a member of the state mechanism or a monastery, was made, a common merchant ship would typically have been made with local rather than imported materials for economic reasons (in the case when the material local to the building site is logistically cheaper to acquire). The suppliers of timber also depended on the nature of commerce during different periods. For example, it can be argued that between 7th and 10th centuries the long distance private shipping was confined to easily transported goods with high profit margins such as silks and textiles.⁴²⁰ Imported timber could be more prominent however, in regions that did not have abundant local resources such as Egypt. Jacoby argues that Byzantine merchants were probably selling timber to Egypt after the second half of the 10th century, whether for private or public use by the state.⁴²¹

State sponsorship, on the one hand, could overcome the economic concerns to a certain level, which is relevant to the investigation of state-constructed warships. It was, however, not always an organized political entity or state that had to construct fleets; the

⁴¹⁷ Kyprouli 2017, 464-65.

⁴¹⁸ Allevato et al. 2009.

⁴¹⁹ Allevato et al. 2009, 37.

⁴²⁰ Kislinger 2019, 337.

⁴²¹ Jacoby 2017, 639.

prominent warship of the Roman Imperial period and the late Empire, namely the *liburnian*, is thought to have descended from the prototype of the Illyrian pirates of the Adriatic, the *lembos*.⁴²² The purpose of their size and construction was to have “speed and maneuverability”.⁴²³ Appian in the *Roman History* while narrating the Illyrian wars mentions the tribe of “the Liburni”, who were nautical people and would use light and fast vessels for piracy along the Adriatic coast. He relates that this was the origin of the Roman’s name for their “light, swift biremes” (App. *Ill.* 10.1.3). In 31 BCE, Octavian defeated Marcus Antonius and Cleopatra’s combined fleet with these smaller but faster and more maneuverable ships. Florus, a Roman historian (74 – 130 CE), described them during the Battle of Actium as “had from two to six banks of oars and no more; being, therefore, easily handled for any maneuver that might be required, whether for attacking, backing water or tacking, they scattered at their will the opposing vessels, which were clumsy and in every respect unwieldy (...)” (Flor. II.21.6). Vegetius later wrote that there were different types of ships but “*liburnian* were better-designed than the rest” (Veg. *Mil.* IV. 33). Thus, constructing warships did not necessarily require the investment of the “Empire”, and could have been constructed by tribes or pirates who may have had limited monetary or logistical resources, but might have had other resources such as abundant local timber—in the case of Illyrian or Cilician pirates—or were highly motivated to obtain them.

The existing archaeological evidence for Byzantine warships, however, are the six galleys that were found at the Theodosian Harbor of Constantinople. It has indeed been pointed out that, the material that was used for them compared to the merchant vessels were “high quality.” Since war galleys at this point would have been built by the state itself, this points to an imperial shipyard, thus, imperial financing to acquire this material.⁴²⁴ As mentioned before, the exploitation of the forests by the state and the private construction was different, and the state could stockpile larger amounts of timber to be used for various ships. The evidence suggests that the construction of naval fleets by the state could have been more organized, with wood acquired in bulk from long

⁴²² Höckmann 1997, 192.

⁴²³ Casson 1995, 125-26, 162.

⁴²⁴ Pulak 2018, 264.

distances if necessary, and private, small-scale construction of merchant ships would acquire the wood in accordance with the commission from local sources.

Therefore, the timber that are included in the initial construction of the ship might give clues about where the ship might have been made, as well as evidence of the trade and logistical networks which supplied the timber. Determining the source of timber for individual shipwrecks have been debated. Nilli Liphshitz, who was responsible for many of the dendroarchaeological analyses of shipwrecks excavated along the coasts of Turkey and Israel, often equates the habitat where all the wood species used in the original construction of the ship can be found together as the region of the shipyard.⁴²⁵ Liphshitz and Pulak propose that “the bulk of the wood used in constructing a hull, especially in antiquity, should be a fairly reliable indicator of the general geographical region where a ship was built.”⁴²⁶ However, they also accept that “wood used in the construction of the ships could have been imported from other regions, represent reused timber from older ships built elsewhere, or repairs made on ships while visiting foreign ports.”⁴²⁷ Regarding the repairs, Liphshitz proposes that use of repairs on a ship can be located due to the presence of “foreign” timbers, made of trees originating from a different geographical region than most of the vessels’ construction timbers.⁴²⁸ The repair then would have been made at a different location, on a stopover during cabotage along the coasts or at a destination port.

On the other hand, an extensively repaired roundship from the Theodosian Harbor, YK 11, likely dating to the second quarter of 7th century CE, suggests otherwise.⁴²⁹ Ingram argues that if the original timbers and the repairs are different, this does not necessarily reflect “construction and repair in two different geographic areas.”⁴³⁰ This is partly related to the fact that the identified original timbers on the ship were not always originally made from a uniform set of tree species. The framing for YK 11 was varied, of oak *Quercus cerris*, pine (*Pinus nigra* and *Pinus brutia*) and tamarisk (*Tamarix* [X5]), as well as sycamore maple (*Acer pseudoplatanus*), and elm (*Ulmus campestris*) for the

⁴²⁵ Liphshitz 2012a, 12.

⁴²⁶ Liphshitz and Pulak 2007/08, 73.

⁴²⁷ Liphshitz and Pulak 2007/08, 73.

⁴²⁸ Liphshitz 2012a, 6.

⁴²⁹ Pulak, Ingram and Jones 2015, 50.

⁴³⁰ Ingram 2018, 132.

futtocks. Ingram assumes that this variety reflects timber availability rather than the shipwright's preference for particular wood species.⁴³¹ Thus, repairs with different timber types than the original construction does not necessarily have to reflect a change of location, which Ingram assumes to be around Constantinople.⁴³² Therefore, Liphschitz's argument cannot be applied to all ships with security.

Additionally, ships might have carried wood aboard for repairs as well, for the repairs that had to be made during the journey. For example, in the miracles of St. Artemios from the 7th century, a shipbuilder is mentioned who had to dive to repair the keel of his vessel on his way to Gaul from Antioch (Artemios, *Mir.* 27). This certainly does not mean that he changed the keel of the ship, but suggest that in most cases urgent repairs had to be done during the journey that could require timber to be reserved in the ship for such occasions especially for long journeys such as the one from the hagiographical account. In Leo VI's *Taktika*, it is also mentioned that the warships should have a shipwright with his tools and extra lumber, planks, hemp, pitch and liquid pitch (Leo VI, *Taktika*, XIX, 5). From these examples, it can be understood that it was very likely for the ships to carry extra timber in the ship especially in the case of warships, and these could have been supplied from anywhere.

4.1.2 Drawbacks of Dendrochronology

Most shipwreck timbers are analyzed through dendrochronological and wood anatomy analysis to determine their dates and species respectively. There are, however, certain problems with these methods and disagreements amongst the specialists. These should be pointed out before discussing the results and the interpretation of these results.

⁴³¹ Ingram 2018, 132.

⁴³² Ingram 2018, 132.

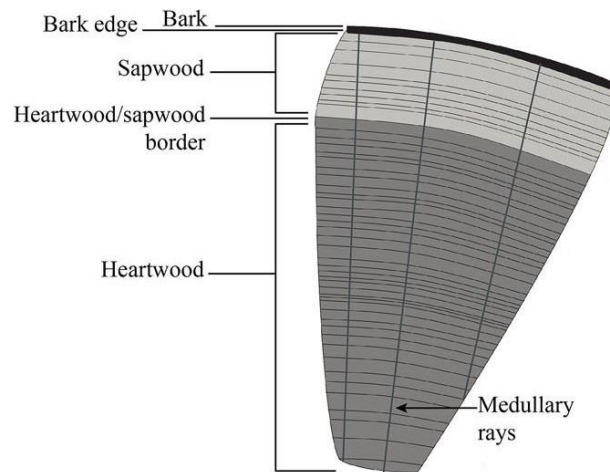
How Does Dendrochronology and Dendroarchaeology Work?

Figure 5 Cross-section of oak. (Domínguez-Delmás et al. 2019, 236.)

It has been mentioned previously that dendrochronology is a scientific method used to date tree rings to the year that they were formed.⁴³³ Most tree species in temperate regions grow one ring of new wood right under the bark each year.⁴³⁴ This ring reflects the climatic conditions under which the tree grew in that year. Thus, “all trees of the same species in the same ‘climatic area’ to record at least some aspects of common growth conditions, and these are represented by growth rings within certain width ranges, which can be measured and compared.”⁴³⁵ With the collection of enough sample material, master chronologies can be constructed. Later samples can be fitted into a master chronology of a region—a process called cross dating—giving an absolute chronology rather than a relative one.⁴³⁶ If this matching is possible, then the dating can be as precise as a year and, for some species, sometimes a felling time within a year (if both the heartwood and the sapwood is present) can be identified (Figure 5).⁴³⁷ Regarding the sampling shipwrecks for dendrochronological analysis, however, caution must be taken to select the adequate timbers. The samples should be suitable for this analysis, and should have sufficient number of rings to be included in a master chronology. For example, it is

⁴³³ Schweingruber 1988, 96; Baillie 1997, 16-7.

⁴³⁴ Monocotyledonous trees and the trees growing in the steady climates of the tropics do not form tree rings. Schweingruber, 1993, 27.

⁴³⁵ Baillie 1997, 16.

⁴³⁶ Baillie 1997, 17.

⁴³⁷ Kuniholm 2008, 182.

not very easy to distinguish the rings of Holm oak (*Quercus ilex*).⁴³⁸ Aleppo pine (*Pinus halepensis*), on the other hand, is very suitable for “chronological, ecological, as well as climatological purposes.”⁴³⁹ Thus, the number of rings needed for dating depend on the species or location of the sample on the tree. Another method that has been in use is wiggle-matching, “where selected decade-long slices cut from a piece of wood at specific intervals are individually radiocarbon-dated, and then the whole array of dates is matched to the radiocarbon curve.”⁴⁴⁰ This is particularly suitable for younger timber examples, which may not have enough growth rings to be matched with an existing chronology.

The identification of the species of the wood –useful to cross date the specimen in the master chronology as well as understanding the construction techniques of the ship– is done through a microscopic examination of the anatomical features of the wood to classify it taxonomically. For the identification of the wood species, a significant number of timbers must be examined, and the samples should not be smaller than 1 cm³.⁴⁴¹ These are much smaller samples than needed for dendrochronological analysis which are larger cross-sections. As quantitative indicators for example, tangential vessel diameters, vessel frequencies (only in diffuse porous wood), ray heights/widths, and intervessel pit size for hardwoods and tangential tracheid diameters, ray heights, and cross-field pits number per field for softwood can be measured for species identification.⁴⁴²

Problems with Dendrochronological and Dendroarchaeological Analysis

In order for dendrochronological analysis to be possible, a certain amount of tree rings must be visible and measurable in the sample for cross dating. Thus, when it comes to shipwrecks, the level of preservation and the lack of suitable tree rings in timber samples is an important obstacle for dendrochronology. To date the wood, a considerable portion of the timber has to be present. The sapwood of the timber often does not preserve as well as heartwood and might be removed by the shipwright during the construction of the ship. However, the samples should include the sapwood, the bark and the waney edge (the wood right below the bark) in order to establish the felling date precisely (Figure

⁴³⁸ Schweingruber 1993, 204.

⁴³⁹ Schweingruber 1993, 128.

⁴⁴⁰ Kuniholm 2001, 7.

⁴⁴¹ Domínguez-Delmás et al. 2019, 232; Akkemik 2015, 12.

⁴⁴² Doğu et al. 2011, 990.

5).⁴⁴³ Kuniholm and Striker points out that in the Byzantine Aegean the maximum elapsed date between cutting the wood and using it was generally only one year.⁴⁴⁴

This is also true for dendroarchaeological analysis for wood identification. The level of preservation changes from one ship to another and affects the number of samples taken from each shipwreck. Therefore, the samples that were taken for analysis differs, for example, 64 samples were analyzed from YK 10, which corresponded to three distinct parts of the ship, frames, starboard planking and stringers, as well as disarticulated timbers from the shipwreck site.⁴⁴⁵ From YK 12, 394 samples were taken, which corresponded to more than ten distinct types of hull timbers of the ship.⁴⁴⁶

In one case, a re-analysis of an older result was made; Yassıada II's initial timber identification was made in 1969 by B.F. Kuchachka of the Forest Product Laboratory, who could only identify the timbers to the genus level but the ship was resampled in 2006 and identification was considered to be possible to the species level by Liphschitz.⁴⁴⁷ The identification of species however is also contested amongst specialists.⁴⁴⁸ For example, Akkemik –who conducted the dendrochronological analysis of the shipwrecks from the Marmaray (Yenikapı) Project that are under study by Istanbul University– argues that the oaks should be classified morphologically into three groups, white, red, and evergreen.⁴⁴⁹ He argues that it is not possible to identify oak down to the species group, and the previous identifications made by Liphschitz and Doğu et al. should be revised.⁴⁵⁰

In a different case, -of Yassıada I- resampling was not possible because the timber remains of the ship were completely lost.⁴⁵¹ Therefore, the published evidence is not consistent, and the analysis in many cases can only give a broad understanding of the timber choices rather than a strict identification of each and every piece of timber that was used in the construction and repair of the ship. Thus, although dendrochronology and

⁴⁴³ Domínguez-Delmás et al. 2019, 235.

⁴⁴⁴ Kuniholm and Striker 1987, 287-88.

⁴⁴⁵ Akkemik 2015, 39.

⁴⁴⁶ Akkemik 2015, 43.

⁴⁴⁷ Liphschitz and Pulak 2007/2008, 75; Liphschitz 2014, 204.

⁴⁴⁸ See for example Wazny 2009, 42.

⁴⁴⁹ Akkemik 2015, 140.

⁴⁵⁰ Akkemik 2015, 140. The works that are referred to is Liphschitz and Pulak 2007/2008 where wood from YK I is identified to be Turkey oak (*Quercus cerris*) and Doğu et al. 2011 where the oak piers excavated at the Yenikapı site are identified down to the species level as well.

⁴⁵¹ Liphschitz 2014, 204.

studies of wood anatomy can provide with valuable information on the dating of the wood as well as its species, discussions amongst the scholars about the application of the method is debated.

4.1.3 *Shipwreck Origin and the Ethnic Identities of Crews*

Lastly, it is not possible to assign any of the discussed shipwrecks to just one regional origin or a particular ethnic identity to the crews. However, certain connections can be observed from the cargo or different elements of the ship's equipment. What can be identified as the personal possessions of the crew of the ship or galley ware (the ceramics that are used on board the ship by crew or passengers and were not for trading purposes) have in some cases been studied as evidence for the identities or origins of individuals on board when possible. Such analyses are very detailed: not only the artefacts, but their locations in the shipwreck and possible uses in the ship should be included. Also, while one artifact from a region represents a connection, many objects of different types from that region might be seen as a possibility of that region being the port of origin, or a port-of-call for the ship.

Some shipwrecks, for example the Serçe Limanı shipwreck dating to the early 11th century, are representative of a complex cultural interaction, in this case, between the Byzantines and Fatimid Syria. Van Doorninck also argues for a Bulgarian presence on the shipwreck based on a variety of objects on board originating from Bulgaria, weapons, fishing weights, Bulgarian-style galley wares, and graffiti on some wine amphoras on board representing Slavic names.⁴⁵² Chemical analysis of the fabric of the galley ware show that their clay was from the northern shore of the Sea of Marmara.⁴⁵³ On the other hand, part of the cargo consisting of 3 metric tons of glass cullet originated from the Syrian coast, and both Fatimid and Byzantine coins and weights were found.⁴⁵⁴ Thus, a complex cultural and ethnic interaction can be seen from one shipwreck.

On the Yassıada I shipwreck from the 7th century, a steelyard was found which may have been owned by a captain and priest based on an inscription on the object, suggesting

⁴⁵² Van Doorninck 2002b, 140.

⁴⁵³ Van Doorninck 2002b, 139.

⁴⁵⁴ Van Doorninck 2002b, 140

a possible connection to monastic activities during this period.⁴⁵⁵ The Tantura B shipwreck found off the Levantine coast, dates to the early 9th century; it has evidence of an “Arab” presence on board. A roundel find, -which is likely a rigging element- had Kufic inscriptions on it, “*aṭher-i ḥuqmullah*”, meaning “Allah has the purest judgement” was associated with the shipwreck.⁴⁵⁶ Therefore, from the artefacts on the ships the presence of individuals from specific ethnic groups who were influenced by specific cultures can sometimes be surmised. However, a definitive identity cannot be securely assigned to most shipwrecks, and such assignments must be made with caution.

4.2 *Shipbuilding in the Mediterranean in 1st Millennium CE*

One of the main factors that affected the shipbuilders’ choice of timber were the construction methods used in the period. Shipbuilding during the Byzantine Empire is in fact is characterized by a transition in shipbuilding methods. The debate on the theoretical background of this transition has been extensive and has been expanded with the addition of new evidence.⁴⁵⁷ Hocker divides shipbuilding concepts into three categories: design, assembly sequence, and structural philosophy.⁴⁵⁸ The design according to him is closely related to the assembly sequence, which is the way in which the ship was physically built, while the structural philosophy is how the shipwright intended the component timbers of the hull to distribute the different working stresses the vessel would encounter.⁴⁵⁹ Pomey, has similarly suggested that shipbuilding process starts with the “conception” phase, where the shipwright conceives the architectural design of the ship, which includes the structural conception (in line with Hocker’s structural philosophy) and the conception of the hull shape.⁴⁶⁰ This is followed by a “realization” phase, in which the actual work of building the ship at the shipyard takes place. Pomey argues that “the notion of construction “principles” is directly associated with the “conception” phase, whereas the notion of construction “processes” or “methods” corresponds to the “realization” phase.”⁴⁶¹ Pulak has recently compiled these various terminologies used to explain this

⁴⁵⁵ Van Doorninck 2002a, 901.

⁴⁵⁶ Wachsmann et al. 1997, 10.

⁴⁵⁷ See Basch 1972; Christensen 1973; Steffy 1994, 1995; Bellabarba 1996; McGrail 1997; Hocker 2004a; Pomey 2004.

⁴⁵⁸ Hocker 2004a, 6.

⁴⁵⁹ Hocker 2004a, 6.

⁴⁶⁰ Pomey 2004, 26-9; 2011 28-34.

⁴⁶¹ Pomey 2012, 32.

change into two general terms; constructional and conceptual approaches to shipbuilding.⁴⁶² The constructional approach refers to “the actual sequence of construction and describes the building methodologies or the sequences with which a ship is physically built,” whereas the conceptual approach relates to “the structural philosophy,” and describes how ancient shipbuilders conceived of the ship; in other words, which timbers provided the primary structural integrity and withstood the stresses acting upon the ship itself.”⁴⁶³ These categories have been proposed to understand the ideas behind different ship construction methods. Deriving from these, two distinct concepts have been identified to explain how the structural strength is incorporated to the hull, which are shell-based and frame-based hulls (defined below). The actual techniques used to build the hull can be more varied, and a “pure” form of either extreme does not necessarily exist, since the shipwrights always used a combination of different approaches and methods.⁴⁶⁴

In 1st millennium CE, the Mediterranean witnessed a gradual and non-linear transition from shell-based ship construction methods to frame-based methods.⁴⁶⁵ In a shell-first construction method, planks are installed before the frames, thus conceptually, they give the hull its shape and some of its integrity. If a shipwright is constructing a ship by this approach, first the keel would be laid, followed by the attachment of bow and stern posts.⁴⁶⁶ Then the planking of the ship is erected, without no frames (or few) supporting this outer shell, and thus the planks have to be edge-joined to each other in order for it to support itself, the planking and the joints often provide much of the structural strength in shell-based hulls. These fastenings that join the hull planks –which may require the hull planks to be thicker compared to other construction methods– which are one of the salient features of shell-based hulls. They are often pegged or unpegged mortise-and-tenon

⁴⁶² Pulak 2018 243-45.

⁴⁶³ Pulak 2018, 243.

⁴⁶⁴ Pomey et al. 2012, 236.

⁴⁶⁵ Pomey et al. 2012, 226-27. Pulak 2018, 242-47. Aside from shell-based and frame-based, several different terms have been used to refer to these construction techniques. For the shell-based, McGrail have used the term “plank-first” (McGrail 1997, 76), and later several scholars have used “shell-first” (Casson 1963, 29–31; Pomey and Rieth 2005, 30; Hocker 2004a, 6; Steffy 1994, 279) or “shell-built” (Steffy 1994, 279). For the transitional shipwrecks, mixed construction (Pomey and Rieth 2005, 33–5; Pomey et al. 2012, 235–6), and intermediate or alternating construction (McGrail 1997, 77–8) have been used. For frame based on the other hand, “framing-first” (McGrail 2015, 385; Pomey and Rieth 2005, 31), “frame oriented” (McGrail 1997, 77–8) “frame-first” (McGrail 1997, 77, 2002, 468), “skeleton-first” (Casson 1963, 28–9), and “skeleton construction” (Greenhill 1995, 284) have been used.

⁴⁶⁶ Whitewright 2016 873-74.

joints. (Figure 7, Figure 8).⁴⁶⁷ The former method was the standard and predominant method of Greek and Roman shipwrights.⁴⁶⁸ Other indications that the hull's strength relies on the planking is the garboards (the lowest hull planks adjacent to the keel) being edge-fastened to a rabbeted or chamfered keel.⁴⁶⁹ The frames are also nailed to the planking and not to the keel or to each other.⁴⁷⁰ This shows that in the shell-based method, the framing elements are not necessarily what the shipbuilder relied on to create the shape or integrity of the ship; instead, this was provided by the planking.



Figure 6 Ravenna, grave stele of Longidienus and Longidiena. (Constable 2005, 173.)

A grave stele dating to late 2nd century CE from Ravenna shows Publius Longidienus, a shipwright, *faber navalis*, son of Publius, busy at work *P(ubli) f(ilius) ad onus / properat*

⁴⁶⁷ Steffy 1994, 83-5.

⁴⁶⁸ Carlson 2011, 386.

⁴⁶⁹ Pulak 2018, 242.

⁴⁷⁰ Pulak 2018, 242.

(CIL XI 139). Casson identifies this depiction as the installation of a framing timber in a hull that was built shell-first (Figure 6).⁴⁷¹

One example to this from the Roman period is the Saint-Gervais 3 shipwreck, found in southern France and dated to the mid-2nd century CE. In this shipwreck, the garboards were edge fastened to the keel with double rows of mortise-and-tenon joints, and the planks were connected to each other by closely set mortise-and-tenon joints.⁴⁷² Pomey et al. characterizes this as the “Roman Imperial” type.⁴⁷³ This edge fastening method was used in Mediterranean shipbuilding since at least the Bronze Age, as evidenced by the Uluburun shipwreck dating to the late 14th century BC, and then gradually developed.⁴⁷⁴

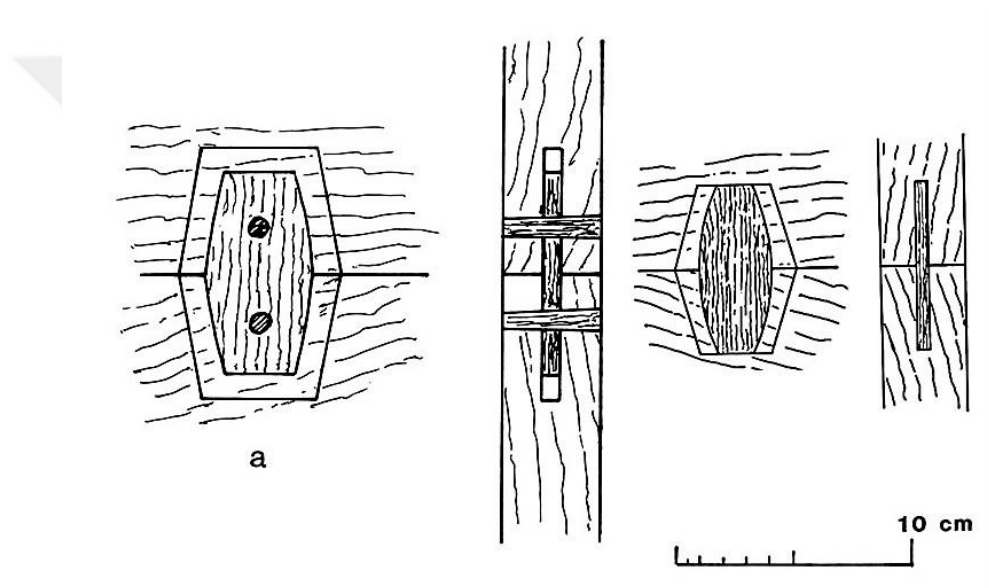


Figure 7 Typical mortise-and-tenon joints from Yassiada II c. 375-425 (on the left, pegged) and Yassiada I c. 625 (on the right, unpegged). (After Pomey 2012, 252, 267.)

In the frame-based construction method, the conceptual approach is the understanding that the vessel's frames create the strength and integrity of the hull. If a shipwright is constructing the ship using this method, he first lays down the keel bow and stern posts, as with a shell-based hull. After that, instead of creating a shell by attaching the planks to each other, the shipwright would erect frames which define the shape of the

⁴⁷¹ Casson 1995, 206, n 24.

⁴⁷² Pomey et al. 2012, 240.

⁴⁷³ Pomey et al. 2012, 241.

⁴⁷⁴ Pulak 1998, 210-13.

hull.⁴⁷⁵ The outer planking is then attached to this skeleton that was created; thus, the hull is shaped by transverse frames fixed to the keel and then reinforced by longitudinal members.

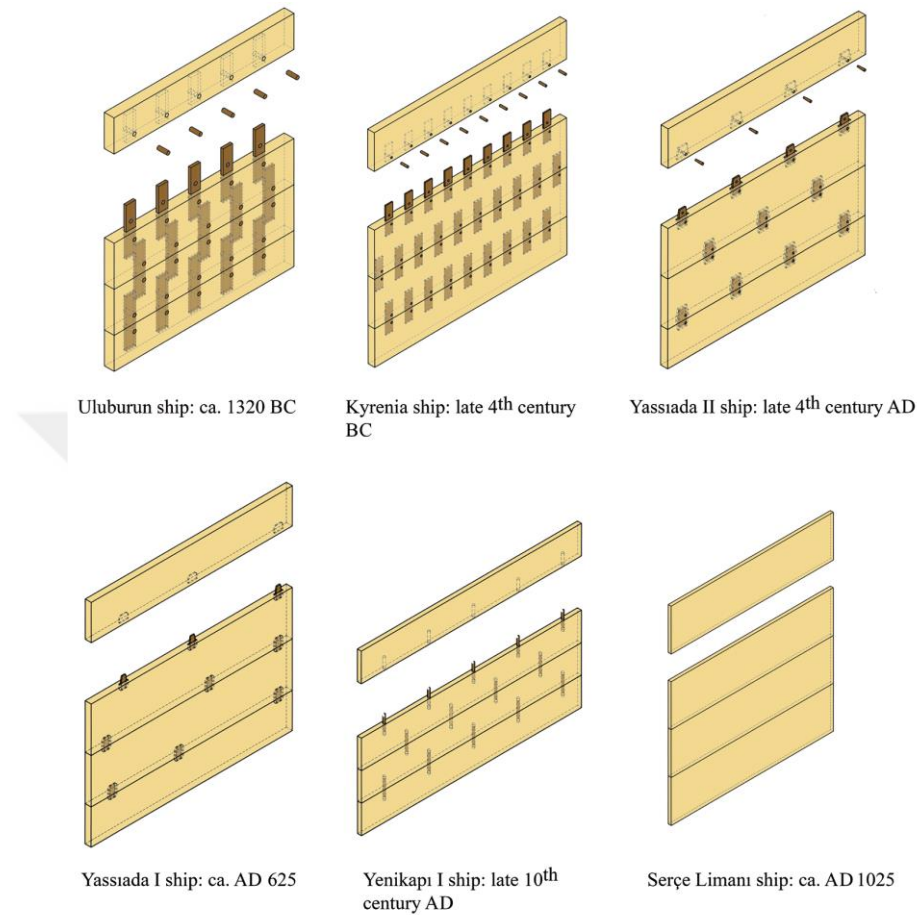


Figure 8 Edge joinery of hull planking from the Late Bronze Age to the late Byzantine period (14th century BC–11th century CE). (Pulak 2018, 274).

Several elements can be pointed out to explain this transition, the mortise-and-tenon joinery for example became smaller and more widely spaced.⁴⁷⁶ This evolution, illustrated by Figure 8, shows a gradual elimination of the mortise-and-tenon joints in the Eastern Mediterranean. The first example, the Uluburun shipwreck from the Late Bronze Age, has pegged mortise-and-tenon-joinery, around 6 cm wide and 30 cm long, which makes them much more robust than the ones in Greek and Roman hulls of the same

⁴⁷⁵ Whitewright 2016, 873-74.

⁴⁷⁶ Steffy 1994, 84.

size.⁴⁷⁷ Pulak theorizes that they actually acted as “small internal frames.”⁴⁷⁸ In the hull of the Kyrenia shipwreck, dating to late-4th century BC, the mortise-and-tenons are smaller, –8 cm long and 2.5 cm wide– but more closely spaced.⁴⁷⁹ The space between the tenons were 20 cm in Uluburun while this is around 12 cm in Kyrenia.⁴⁸⁰

While still being pegged, the joints are more widely spaced in Yassiada II shipwreck from 4th century CE, around 20 cm.⁴⁸¹ Three centuries later in the hull of the Yassiada I shipwreck, the mortise-and-tenon joinery is not pegged and had become significantly smaller compared to the early examples: the space between them ranging from 35 to 50 cm.⁴⁸² This can also be seen from Figure 7, in which both mortise-and-tenons are shown at the same scale and the Yassiada I joints are much smaller. The mortises were larger than the tenons: thus, their primary purpose was not fasten the planks together during construction rather than provide significant additional strength to the hull.⁴⁸³ None of this edge joinery can be observed in Serçe Limanı shipwreck, dating to c. 1025 CE. This shipwreck has been identified as the final step in this transition to the frame based construction method, it had frames designed using a simple geometrical formula, erected on a number of different points on the keel before the planking was added.⁴⁸⁴ The hull-shape was predetermined by the midship-frame and five other frames, and this style of construction became dominant in the Mediterranean.⁴⁸⁵

Most of the shipwrecks that were recovered in the Mediterranean from Late Antiquity and the Middle Byzantine period combine the use of both of both shell-based and frame-based construction methods.⁴⁸⁶ Since they do not presuppose either end of the spectrum, they are called alternating or mixed ship construction. Yassiada I and most of the Yenikapı roundship for example were built with shell-based method until the water line, and the upper hull was frame-based. Due to this, it can be said that they are closer to

⁴⁷⁷ Pulak 2002, 629.

⁴⁷⁸ Pulak 2002, 629.

⁴⁷⁹ Steffy 1985, 81.

⁴⁸⁰ Steffy 1985, 89; Pulak 2002, 629.

⁴⁸¹ Van Doorninck 1976, 123.

⁴⁸² Van Doorninck 1982, 55.

⁴⁸³ Steffy 1982, 73.

⁴⁸⁴ Steffy 2004, 154–65.

⁴⁸⁵ Pomey 2012, 277.

⁴⁸⁶ McGrail 1997, 77–8; Pomey et al. 2012, 235–36; Pulak 2018, 245.

a shell-based construction. Most of the shipwrecks from the Byzantine period, if not all, fall into this transition phase.

The mixed construction method in fact was used for a long period in the Mediterranean. This method was very adaptable, and allowed ships to be built even with low quality timber. One example to this is the Sea of Galilee boat dating to 1st century BCE–late 1st century CE.⁴⁸⁷ According to a preliminary hull construction report by Steffy, the boat was built using shell-based methods (pegged mortise-and-tenon joints) until at least the 6th strake, after which some floor timbers were likely placed before rest of the planking was erected.⁴⁸⁸ For the construction of the planks, many small pieces of recycled wood were joined together edge-to-edge, and this was possible with mortise-and-tenon joinery.⁴⁸⁹ Thus, smaller, low quality pieces of timber could be used in the construction of the ship.

The transition from construction of shell-based to frame-based hulls in the Mediterranean can be examined through the advantages and disadvantages of each method including how shipbuilding was adapted to the changing social and economic conditions. In shell-based construction before Late Antiquity the framing was generally weaker; however, thick planking and mortise-and-tenon joinery contributed to strong and rigid hulls.⁴⁹⁰ In order for mortises of a significant size to be carved, the planks had to be thick, and tenons had to be shaped and placed accordingly between the two corresponding planks, thus it used more wood and required more labor. This for example can be observed from the mortise-and-tenon joinery used on the Uluburun and Kyrenia shipwrecks (Figure 8), in which the mortise-and-tenon joints are both large and closely spaced. Steffy argues that these hulls, such as the Kyrenia shipwreck was “labor intensive and rather wasteful of materials.”⁴⁹¹ The shell-based hull then did not require more elaborate methods used to design frame-based ships and was a strong hull, but used a lot of material, labor and time to be constructed.

⁴⁸⁷ Wachsmann 1990, 130.

⁴⁸⁸ Steffy 1990, 39.

⁴⁸⁹ Wachsmann 2000, 143.

⁴⁹⁰ Steffy 1994, 84.

⁴⁹¹ Steffy 1994, 85.

A frame-based hull's shape, on the other hand, could be accurately planned before the assembly, as frames could be cut and shaped beforehand. This would give the shipwright the ability to determine certain hull characteristics more precisely, such as its cross-section or its eventual size. In addition to this, the hull planks and frames could be installed simultaneously, where after putting up the pre-designated frames, the builder could alternate between planks and frames, saving time.⁴⁹² Since the integrity of the ship did not only depend on hull planking but was also provided by the frames and longitudinal timbers such as the keel, keelson and stringers, the edge joinery, whether mortise-and-tenon joints, dowels or coaks, became smaller and were spaced wider (Figure 8). These mostly acted as pieces for alignment, eventually disappearing, removing the need to spend both material and time in installing them. This allowed the shipwrights to save both "time and timber."⁴⁹³ Steffy mentions that with unpegged mortise-and-tenon joints, the shipwright could use a light nailing pattern as an economy measure.⁴⁹⁴ In addition to this, there was a shift from copper nails to cheaper iron ones around 4th century CE.⁴⁹⁵ Van Doorninck suggests that in contrast to long-lived Greco-Roman vessels, ships became more affordable.⁴⁹⁶ This change could have been prompted by different factors, and theoretically ships could now be produced faster with less cost, which would also serve private shippers who did not have the resources that the imperial state had. Larger ships, or ships with specialized designs such as warships on the other hand, could also be constructed more easily, as hull shape could be more accurately predetermined.

Another theory is about the change in labor type from the Roman period to the Medieval, when the concept of slavery was transformed.⁴⁹⁷ There were also fewer slaves, during the Roman imperial period one of the most important source of slaves were war prisoners, and during the conflict between the Byzantines and the Arabs starting in the 7th century for example the norm was to exchange these prisoners, and not sell them as slaves.⁴⁹⁸ If shipbuilding was dependent on slaves during the Roman period, this might

⁴⁹² Steffy 1994, 85.

⁴⁹³ Steffy 1994, 85.

⁴⁹⁴ Steffy 1982a, 82.

⁴⁹⁵ Pomey et al. 2012, 297.

⁴⁹⁶ Van Doorninck 2002a 900.

⁴⁹⁷ Rotman 2009, 5-12.

⁴⁹⁸ Rotman 2016, 130.

be an important transition to highlight; however more this would require more research on the shipyard workers of both the Roman and Byzantine periods.

Maintenance of frame-based hulls without mortise-and-tenon joints were also easier compared to shell-based hulls, as the lack of edge-joinery made it easier to dismantle certain parts, especially the hull planking, to replace or repair them. Therefore, this method required less capital in the short term and less maintenance cost on the long run. Economizing in construction and repairs has been observed from several shipwrecks from the Theodosian Harbor.⁴⁹⁹ Kahanov and Royal also theorize that especially the smaller, regionally operating merchant ships which have a smaller profit margin would be more motivated to experiment with new technologies that might require less time, timber and labor.⁵⁰⁰ From this evidence, it can be suggested that the transformation of shipbuilding practices was slow, but in general, compatible with the socio-economic transformations in the Mediterranean. However, it should also be kept in mind that since the evidence is limited, the connection between certain shipbuilding methods and social, economic, and political conditions of the period is yet theoretical.

Economic considerations also affected the decision-making about the types of timber to be used. There might have been “ideal” materials, such as using fir for the outer hull planking and oak for the keel as Theophrastus have recommended (*Theophr. Hist. pl.* V.vii.1-3). However, from the examples that will be discussed, it seems that the shipwright was adapting to the conditions rather than building the ships in accordance with an ideal model. Many factors affect the selection of timber for a ship, such as availability, logistics of acquisition, or performance of different tree types, but especially economic considerations are crucial.⁵⁰¹ Therefore, a compromise could be made between trees with similar woods (such as light and tall for hull planking); instead of Silver fir (*Abies alba*) as Theophrastus mentions for example, Mediterranean cypress (*Cupressus sempervirens*) could be used. The timber that was the easiest to acquire, which would be suitable for the part for which it was intended on the ship, would be the priority of the shipwright, especially in private shipbuilding.

⁴⁹⁹ Jones 2017, 280; Ingram 2018, 131-32.

⁵⁰⁰ Kahanov and Royal 2004, 126.

⁵⁰¹ Rival 1991, 89-90.

4.3 *The Shipwreck Assemblages*

The shipwrecks will be analyzed based on the region in which they were discovered. Thus, they are divided into three categories: the shipwrecks that were found in the Mediterranean and Aegean coast of Asia Minor, the Levant, and the Theodosian Harbor excavations at Yenikapı in Istanbul (Figure 9). In order to determine the origin and the route of each shipwreck, not only the timber that was used in the construction and the repairs should be analyzed, but also the cargo of the ship (when it is present) must be studied. Therefore, this categorization disregards the origin and the route of the ships and is based on the locations where the ship has been found.



Figure 9 Map of the locations of the shipwrecks discussed in this section.

4.3.1 Mediterranean and Aegean Coasts of Asia Minor

Four shipwrecks that were found on the Mediterranean and Aegean Coasts of Asia Minor that will be included in the analysis are the Yassıada II, Yassıada I, Bozburun and Serçe Limanı shipwrecks, all of which were excavated and documented by the Institute of Nautical Archaeology. Table 4-1 illustrates the dominant tree or trees from the samples taken from the keel, frames and planking of each ship.

Table 4-1 Selected Shipwrecks from Mediterranean and Aegean Coasts of Asia Minor

		Part of the Ship		
Ship	Date of Construction / Sinking	Keel	Frames	Hull Planking
Yassıada II ⁵⁰²	c. 375-425	White oak (<i>Quercus</i>)	Turkey oak (<i>Quercus cerris</i>)	Mediterranean cypress (<i>Cupressus sempervirens</i>)
Yassıada I ⁵⁰³	c. 625	Mediterranean cypress (<i>Cupressus sempervirens</i>)	Elm (<i>Ulmus</i>)	Pine (<i>Pinus</i> sp.)
Bozburun ⁵⁰⁴	c. 874	Turkey oak (<i>Quercus cerris</i>)	Turkish pine (<i>Pinus brutia</i>) Turkey oak (<i>Quercus cerris</i>)	Turkey oak (<i>Quercus cerris</i>)
Serçe Limanı ⁵⁰⁵	c. 1025	Turkish pine (<i>Pinus brutia</i>)	Turkish pine (<i>Pinus brutia</i>)	Turkish pine (<i>Pinus brutia</i>)

⁵⁰² Bass and van Doorninck. 1971; van Doorninck 1976; Steffy, 1994: 79–80; Liphshitz and Pulak 2007/2008, 75; Liphshitz, 2014b, 75.

⁵⁰³ Bass and van Doorninck 1982; Steffy, 1994: 80–85; Liphshitz, 2014b.

⁵⁰⁴ Harpster 2002; 2005a; 2005b; 2009; Liphshitz and Pulak. 2007/2008.

⁵⁰⁵ Steffy 1982b; Steffy 1994, 85–91; Matthews and Steffy 2004, 81–122; Liphshitz and Pulak 2007/2008.

Yassiada II

The oldest shipwreck in this assemblage is Yassiada II, dating to the Late Roman Empire (c.375-425 CE).⁵⁰⁶ It was found close to modern day Yassiada in Bodrum, on the southern Aegean coast of Turkey. The wreck was dated on the basis of the pottery finds discovered on board.⁵⁰⁷ The hull-remains were 16 m long by 5.2 m wide, and the original length is estimated to be around 20 m to 8 m.⁵⁰⁸ Its framing system consists of floor timbers alternating with paired half-frames, which is the traditional Greco-Roman framing system, the planks are joined by pegged mortise-and-tenon joints, and the hull cross section is wine-glass shaped (Figure 10).⁵⁰⁹ Bass and van Doorninck state that two main types of timber were used in the construction: the sternpost, outer hull planking, wales, frames and floors, ceiling planking and smaller pegs used in the mortise-and-tenon joints were of Mediterranean cypress (*Cupressus sempervirens*); tenons and large treenails which were used to fasten the frames to the outer hull planking on the other hand were made from evergreen oak, and the keel is white oak.⁵¹⁰ In this region, Holm oak (*Quercus ilex*) and Kermes oak (*Quercus coccifera*) are endemic evergreen oaks. These were the results from the analysis prior to the 1976 publication on the hull; the wood was re-sampled in 2005. This second analysis indicated that the planks were indeed made from Mediterranean cypress (*Cupressus sempervirens*) and the frames and treenails were identified as Turkey oak (*Quercus cerris*); one frame was identified as Turkish pine (*Pinus brutia*) and two unidentified timbers as Oriental beech (*Fagus orientalis*).⁵¹¹ From this data and the distribution of the trees, Liphschitz concludes that the ship might have been built along the southwestern coast of Asia Minor.⁵¹² If this argument is accepted, it also shows that the ship did not sink far away from the location of its construction.

⁵⁰⁶ Bass and van Doorninck 1971; van Doorninck 1976; van Doorninck 1982, 32-64; Steffy 1994, 79-80.

⁵⁰⁷ Bass and van Doorninck 1971, 75.

⁵⁰⁸ Pomey et al. 2012, 250-52.

⁵⁰⁹ Pulak 2018, 283.

⁵¹⁰ Bass and van Doorninck 1971, 33. Live oak is a general term for a number of unrelated evergreen oaks; white oak, on the other hand, may refer to many of various trees from the genus *Quercus*.

⁵¹¹ Liphschitz and Pulak 2007/2008, 75.

⁵¹² Liphschitz and Pulak 2007/2008, 75; Liphschitz 2014, 204.

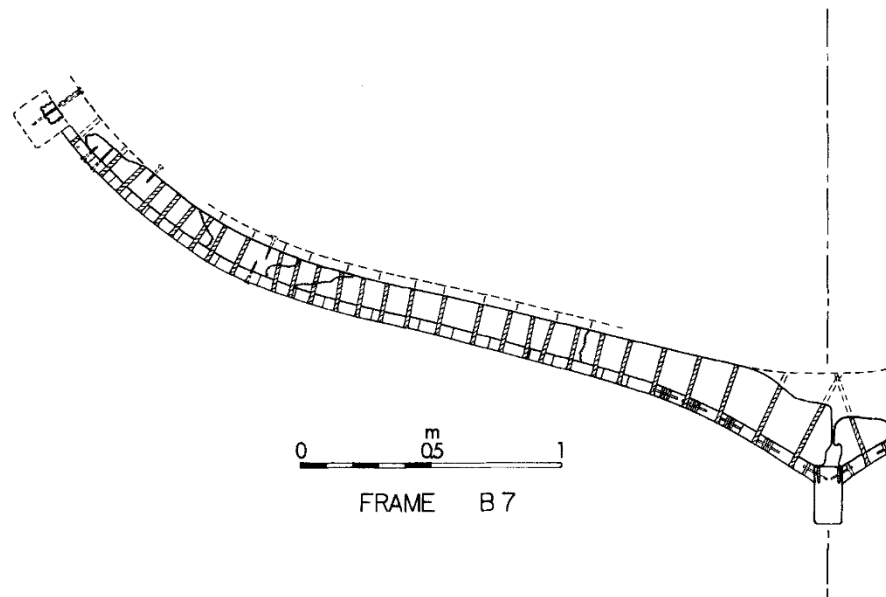


Figure 10 Cross section of Yassiada II shipwreck at midships frame, a wine-glass shaped hull. (van Doorninck 1976, 118)

Van Doorninck suggests that the shipwright was careful to “make the fullest possible use” of the wood he had.⁵¹³ He identifies that scrap wood was used for framing; some of the futtocks were short (A-1, B-2, 4 and 11), and some planks were narrow (P-4, 6, 8, 11, and 14). They apparently were cut from small logs and the shipwright had to accommodate by making the scarfs on the planks “extremely” long.⁵¹⁴ The longest was the after scarf in P-14, over 2.3 m.⁵¹⁵ He also observed that some of the planks had a large number of knots, which he suggests may indicate a shortage of better-quality shipbuilding timber. Overall, from these observations it appears that the Yassiada II ship may not have been built with high quality timber, and the pieces that were used were short and thus the shipwright had to adjust his construction methods accordingly. On the other hand, the timber used for the construction of the planks, Mediterranean Cypress (*Cupressus sempervirens*) can grow up to 40 m in length, and it is monopodial (grows straight), thus it is interesting to observe the use of short planks with this species.⁵¹⁶ One might consider the use of scrap material, and material that was left from other ships. Oaks, which are also found as frames on Yassiada II, are used very commonly for structures that need water

⁵¹³ van Doorninck 1976, 130; Liphschitz 2014, 204.

⁵¹⁴ van Doorninck 1976, 130.

⁵¹⁵ Van Doorninck 1976, 121.

⁵¹⁶ Farjon 2017, 322.

tightness, as its vascular vessels are blocked with thyl, liquids cannot penetrate through.⁵¹⁷ Turkey oak (*Quercus cerris*) on the other hand is liable to shrinkage and is susceptible to rotting.⁵¹⁸ Therefore, the preference of this species might have been related to compass timbers that it could supply, easy access, or the lack of better oak species.

Yassiada II is in fact the earliest dating shipwreck in the Mediterranean where cypress (*Cupressus sempervirens*) was used. Liphshitz argues that the use of cypress (*Cupressus sempervirens*) was limited to the Roman period in the Mediterranean, because it was the Romans who cultivated it in order to use it for shipbuilding. Several finds support that cypress was cultivated by the Romans; for example, in the Italian peninsula, its remains were attested from as early as Bronze Age.⁵¹⁹ Liphshitz also argues that the reason why it was no longer being used after the 8th century was due to over-exploitation of the tree, which is not a species that regenerates easily.⁵²⁰ However, the use of cypress as shipbuilding material is not limited to the Roman period. YK 30, for example, which dates to 700-900 CE has cypress as the main hull planking species used in its construction, which shows that the use of this specific species was not limited to the Roman period.⁵²¹ However, Liphshitz' argument should not be dismissed, cypress could have become rare due to overexploitation in some regions and could be used in different regions; further research and data is required to limit the cultivation of cypress to the Roman period.

Yassiada I

The second shipwreck from this group is Yassiada I, found in a very close proximity to Yassiada II.⁵²² This ship, however, dates to after 625 CE, the reign of Emperor Heraclius (c. 610-641), and has been associated by van Doorninck with the military supply system *-annona militaris-* of his Persian campaign.⁵²³ The ship was carrying around 900 amphoras, presumably filled with oil and wine.⁵²⁴ This dating was possible through the coin finds, which gave the *terminus post quem* for the shipwreck.⁵²⁵ The ships

⁵¹⁷ Akkemik 2015, 176.

⁵¹⁸ Liphshitz and Pulak 2007/2008, 170.

⁵¹⁹ D'auria et al. 2020, 16.

⁵²⁰ Liphshitz 2013, 91.

⁵²¹ Akkemik 2015, 110-13.

⁵²² Steffy 1982a; van Doorninck 1982; Steffy 1994, 80-3; Pomey 2004, 32-3.

⁵²³ van Doorninck 2015, 205-16.

⁵²⁴ van Doorninck 2015, 206.

⁵²⁵ Fagerlie 1982, 146. Kuniholm has stated that the dating was not possible through the dendrochronological analysis of the keel, See Kuniholm 1982, 326.

dimensions are reconstructed as 20.52 m in length, with a maximum width of 5.2 m.⁵²⁶ The construction methods resemble Yassiada II: the framing system utilized floor timbers alternating with paired half-frames and the hull cross section is wine-glass shaped, which was the most common framing system for shell-based hulls in the Mediterranean (see Figure 10 for the wine-glass hull of Yassiada II).⁵²⁷ However, the mortise-and-tenon joinery in this example were not pegged, and were much smaller and widely spaced compared to the 4th century ship (see Figure 7 for the comparison). Also, tenons were smaller than the mortises, thus when two planks were to be put together, it did not require perfect alignment. This shows that the mortise-and-tenons were not placed to strengthen the hull but were used primarily for longitudinal alignment, or as aids in construction.⁵²⁸ This must have cut the construction costs, time and effort compared to a hull with a densely spaced mortise-and-tenon pattern. If the shipwright is not relying on the edge fasteners as a major part of the hull strength, having them widely spaced is a more flexible design method. The keel, sternpost, wales, through-beams and ceiling strakes were made of cypress (*Cupressus sempervirens*); planking, false sternpost and hanging knees from pine (*Pinus*) and elm (*Ulmus*) for frames, white oak (*Quercus*) for tenons.⁵²⁹ However, due to a fire in the laboratory, no further studies were done about Yassiada I.⁵³⁰ From the present information, however, Liphschitz concludes that in both of the Yassiada wrecks, Mediterranean cypress (*Cupressus sempervirens*) was the dominant timber used in their construction, which is convenient for underwater constructions.⁵³¹

Bozburun

The two shipwrecks found in this region after Yassiada I show a variety in construction techniques. In the construction of the Bozburun shipwreck, for example, is mortise-and-tenon joints were abandoned and coaks/dowels were used.⁵³² Harpster has

⁵²⁶ Pomey et al. 2012, 266–68.

⁵²⁷ Pulak 2018, 283.

⁵²⁸ Van Doorninck 1982, 55.

⁵²⁹ van Doorninck 1982, 55; Liphschitz 2014, 204.

⁵³⁰ Liphschitz 2014, 204.

⁵³¹ Akkemik 2015, 151.

⁵³² Harpster 2002; 2005a; 2005b, 2009. Steffy defines a coak as “A rectangular or cylindrical pin let into the ends or seams of timbers about to be joined in order to align or strengthen the union.” (Steffy 1994, 269) On the other hand, a dowel is “A cylindrical piece of wood (of constant diameter) used to align two members by being sunk into each. A cylindrical coak. Unlike treenails or pegs, dowels served an alignment function only, additional fastenings being necessary to prevent separation of the joint.” (Steffy 1994, 270). Different researchers have used different terms for this; however, they refer to the same type of fastener.

identified these members on the Bozburun shipwreck as dowels, which he argues that were used “(...) temporarily to align the planks before they were fixed to the framing.”⁵³³ The original Bozburun ship would have been around 15 m long and around 5 m wide, with an estimated 30% of the hull surviving.⁵³⁴ The hull cross section is also shallower compared to the Yassiada ships.⁵³⁵ The amphoras on the ship has been dated to the later 9th century, meanwhile the dendrochronological analysis has indicated that the oak timbers were cut in CE 874.⁵³⁶ Most of the elements of the ship were identified in Harpster’s 2005 dissertation as oak (*Quercus*) without identification of timbers to the species level, as well as Turkish pine (*Pinus brutia*) and chestnut (*Castanea*). Hocker had previously published the suggestion that the oak might in fact be Holm oak (*Quercus ilex*).⁵³⁷ Liphschitz, on the other hand, has published in the 2007/8 article that most of the ship was made of Turkey oak (*Quercus cerris*) including the keel, stem, floor timbers, hull planking, a futtock and a treenail. Turkish pine (*Pinus brutia*) was used in the construction of futtocks and floor timbers on the sides of the center.⁵³⁸ The hull was built with an oak keel, seven oak floor timbers, approximately 27 pine floor timbers, and oak planking.⁵³⁹ Harpster also observes after the excavation that pine floor timbers were stronger, and more durable, have suffered less wear and erosion, and tend to have crisper and cleaner edges and faces compared to the oak ones.⁵⁴⁰ Regarding the construction site, Liphschitz concludes that the ship was probably built in southern or western Asia Minor, not far from where the ship sank.⁵⁴¹

Serçe Limanı

The last ship in this group is the Serçe Limanı shipwreck, which sank around c. 1025, after a long period of service evidenced by the repairs.⁵⁴² Its dating is based on the latest of sixteen Fatimid glass weights, which date to 1022/25 as well as the coins of Emperor

⁵³³ Harpster 2005b, 93.

⁵³⁴ Pomey et al. 2012, 273–74.

⁵³⁵ Pulak 2018, 284.

⁵³⁶ Harpster 2005a, 7.

⁵³⁷ Hocker 1998, 9.

⁵³⁸ Harpster 2002.

⁵³⁹ Harpster 2002, 412. The number of pine floor timbers increases from 25 (Harpster 2002, 412) to 27 (Harpster 2005a, 136).

⁵⁴⁰ Harpster 2002, 412.

⁵⁴¹ Liphschitz and Pulak 2007/2008, 75.

⁵⁴² Steffy 1982b, 1994, 85–91; 2004, 165.

Basil II (r. 976–1025).⁵⁴³ The shipwreck was found off the coast of Marmaris in Western Asia Minor, where the Aegean and the Mediterranean meet. The hull was consisted of flat floor timbers and a round turn of the bilge (Figure 11).⁵⁴⁴ As mentioned before, its most prominent surviving cargo was 3 tons of Fatimid glass cullet.⁵⁴⁵ The ship is reconstructed to be around 15.66 m to 5.3 m, and compared to the early vessels found in the same region has a different construction.⁵⁴⁶ Alternating L-shaped floor timbers are used in its framing, no edge joinery could be found, and the regular spacing and dimensions of the timbers, which was very close to a Byzantine foot, 31.23 cm, has lead scholars to conclude for a pre-planned, frame-first construction technique.⁵⁴⁷ In fact, the Serçe Limanı shipwreck has often been identified as the earliest known hull to have completed the transitions from shell-first to frame-first construction in the Mediterranean.

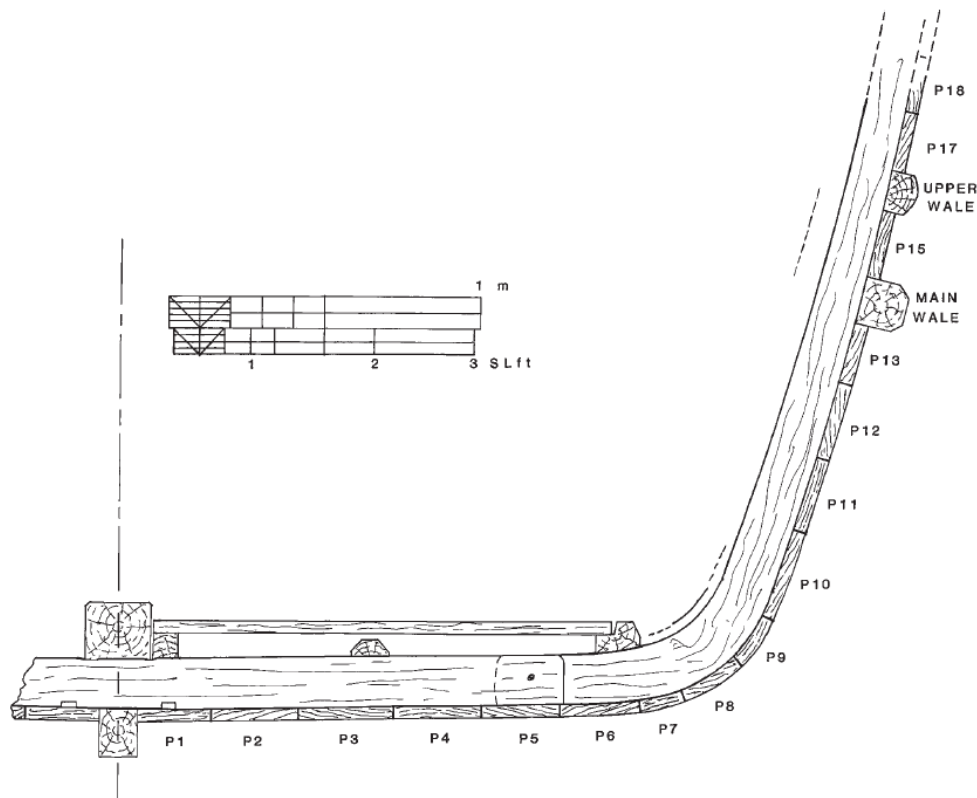


Figure 11 Sectional view of the port side of the Serçe Limanı shipwreck hull amidships, showing the flat floor timbers and the round turn of the bilge. (Steffy 2004, 160)

⁵⁴³ Bass 2004, 8 n.1.

⁵⁴⁴ Pulak 2018, 285.

⁵⁴⁵ This has been discussed in the second volume of the final report on the shipwreck, Bass et al. 2009.

⁵⁴⁶ Matthews and Steffy 2004, 81–122; Steffy 2004, 153–69; Pomey et al. 2012, 277–78.

⁵⁴⁷ Pomey et al. 2012, 277–78. This measurement is reconstructed by Schilbach 1970, 19.

The sternpost, keelson, frames, wales, planks was made from Turkish pine (*Pinus brutia*).⁵⁴⁸ In the 2004 publication of the first volume of the Serçe Limanı shipwreck final report, it is noted that the keel was identified as possibly a species of elm (*Ulmus*).⁵⁴⁹ Liphshitz and Pulak, on the other hand, identify it as Turkish pine (*Pinus brutia*) based on a 2005 reanalysis of the wood.⁵⁵⁰ The main component of the ship, Turkish pine (*Pinus brutia*) has a wide distribution around the Aegean and the Mediterranean coasts of Asia Minor; however, Liphshitz argues that the ship was built in the Northern Aegean region based on the archaeological finds, which still cannot be determined with certainty.⁵⁵¹ This had previously been discussed by van Doorninck, and he concluded that the home port of Serçe Limanı shipwreck would have been the northern shore of the Sea of Marmara.⁵⁵² It is noteworthy, however, that although Liphshitz argues primarily for a wider geographical range for the possible construction location of the ship, in Turkey, Aegean or the Mediterranean coasts, the reason why the location could be more specific was due to the archaeological finds from the ship, many of which, appear to be connected to the Marmara region.⁵⁵³ Turkish pine (*Pinus brutia*) on the other hand grows up to 30 m with a diameter at breast height of around 1.5 m.⁵⁵⁴ Thus, it can supply long and wide planks for the hull. Some of these planks of Serçe Limanı shipwreck were up to 30 cm wide, however the lengths were not possible to determine due to the poor preservation of the hull planking.⁵⁵⁵ Turkish pine (*Pinus brutia*) is one of the easiest pines to grow in the Mediterranean climate, usually in lower altitudes, so the shipwright might have had this species easily at his disposal.⁵⁵⁶

When analyzing the construction of the vessel, Steffy argued that twelve nearly identical pine logs, each at least 3.2 m and with a branch angling away at around 72° would be used for the ten standing frames (see Figure 11 for the frames).⁵⁵⁷ Here it can be

⁵⁴⁸ Liphshitz and Pulak 2007/2008, 75.

⁵⁴⁹ Matthews and Steffy 2004, 86. These analyses were completed by Donna J. Christensen of the Center for Wood Anatomy Research, U.S. Forest Products Laboratory (USDA), Madison, Wisconsin.

⁵⁵⁰ Liphshitz and Pulak 2007/2008, 75.

⁵⁵¹ Liphshitz and Pulak 2007/2008, 75.

⁵⁵² Van Doorninck 2002b, 139. Van Doorninck also argues that the ship was built in Antioch due to the presence of vast Turkish pine (*Pinus brutia*) distribution in the region. See Van Doorninck 2012, 132.

⁵⁵³ Liphshitz and Pulak 2007/2008, 75.

⁵⁵⁴ Farjon 2017, 660.

⁵⁵⁵ Steffy 1982, 23.

⁵⁵⁶ Farjon 2017, 661.

⁵⁵⁷ Steffy 2004, 156.

seen that it is not only the length of the logs that is important, but the identical angle of the branching would be crucial to have intact frames. For the planks, he argues that they were “simple pine boards sawn to a thickness of 4 cm.”⁵⁵⁸ This might also show why in some cases frames would have a variety of species used in construction, meanwhile the hull planking could be made from one species; as long as there are trees with straight trunks supplied for construction (such as conifers) planks can be extracted, but the identical angles of the frames are harder to acquire, forcing the shipwrights to prioritise the shapes and angles of the branches rather than having a uniform species with suitable characteristics.

Conclusions

Overall, these four shipwrecks are too small of a dataset to discuss the general shipbuilding trends in western Anatolia. However they are useful to analyze the individual decision making of the shipwrights that built them. New finds on the other hand, could allow for better generalizations in the future. For the period that covers Yassıada II and Yassıada I shipwrecks, which is from the 4th to the 7th century CE, Leidwanger argues for a regionalization in trade patterns. In his study of 54 shipwrecks dating to 3rd century BCE – 7th century CE, from the southwest Aegean coast of Turkey which covers from Bodrum to Kaş, and shows that after 4th century CE, there is a decline in long distance amphora imports (such as types from North Africa and the Adriatic).⁵⁵⁹ This might be pointing to a more region-based trade network and less long distance, Mediterranean-wide trade. This also might be in line with Liphschitz’ argument for Yassıada II and I shipwrecks, in which the ships that were found in this region were probably made in this region. However, it has already been mentioned that Yassıada I shipwreck might have been involved with Heraclius’ Persian campaign, and its sinking in the Aegean was simply an accident on the way to the eastern coast of Asia Minor or the Levant, and although the ship might have been made in the Aegean, it did not necessarily operate in that region. Thus, the individual study of each shipwreck might have drawn a different picture about this regionalization. The 11th century Serçe Limanı

⁵⁵⁸ Steffy 2004, 161.

⁵⁵⁹ Leidwanger 2017, 611.

shipwreck, for example, with the varied geographical origins of its cargo, shows that long-distance trade was still continuing, on perhaps a smaller scale.

It can be said that in this region there is not a specific chronological change in the timber types used by the shipwrights. Although this is a small sample group, the timber types are show the general preference for shipbuilding. Both conifers, especially cypress and pine, and broad-leaved trees such as oak are used interchangeably in the different parts of the ships. Additionally, a certain economization in the use of timber in Yassiada II (375-475 CE) was commented upon by van Doorninck; however, Leidwanger's study of identified late antique shipwrecks from this region suggests not an economic decline, but a period of prosperity, especially at the beginning of the 5th century.⁵⁶⁰ During this period corresponding to the reign of Emperor Theodosius II (r. 401 – 450 CE) a general prosperity can be seen around the coasts of Asia Minor.⁵⁶¹ It must be underlined that with the inauguration of Constantinople as the capital of the empire in 330 CE, Eastern Mediterranean became the focus of commercial activities, exemplified by the expansion of the *annona* and directing much of the grain supply from Alexandria and other locations to Constantinople, and the establishment of the Carthage/Constantinople axis.⁵⁶² Therefore the trade in the Aegean, being *en route* to Constantinople was also flourishing not only due to the long distance journeys of *annona* ships, but also the transshipments exemplified by the regional centers. Therefore, in the case of Yassiada II, the economization of the material and labor which van Doorninck identifies was most likely was on an individual level rather than being the direct result of the general economic trends. This shows that the major economic trends that dominate the macro-level economic systems might not be an accurate representation of the local and regional realities. Thus, the economy of the empire in general cannot necessarily be taken as an indication of each shipwright or merchants economic prosperity level. Also, cheaper ships does not necessarily mean less economic prosperity or commerce, but could mean more ships being built. However, it must be kept in mind that both the shipwrecks that were excavated and discussed in the context of shipbuilding timber and the shipwrecks that were surveyed are a small percentage of the original ships operating in the area, so there

⁵⁶⁰ Leidwanger 2017, 605.

⁵⁶¹ Niewöhner 2007, 43.

⁵⁶² Cameron 1993, 101.

are limits to the interpretations of this material as reflections of the larger economic trends.

4.3.2 *Levant*

The ships that were found in the Tantura/Dor in modern day Israel, in comparison to the Yenikapı and the Aegean-Southern Asia Minor assemblages, exhibit different construction techniques. Due to their size and shape, some of them are assumed to be local coasters. Here, eight of the shipwrecks will be analyzed (Tantura A, Dor 2001/1, Dor 2006, Tantura E, Tantura F, Ma'agan Mikhael B, Tantura B), and although the later three date to the Islamic domination in the region, they will be included to question continuity in the shipbuilding timber preferences in the region.⁵⁶³ There are other shipwrecks excavated from the bay such as Dor D, however there are not sufficient hull remains or analysis and thus they have not been included.⁵⁶⁴ Pomey et al. identifies shipwrecks Dor 2001/1, Tantura A, Tantura B, Tantura F, and Tantura E as belonging to a “bottom based construction”, which is a shallow-water, riverine construction tradition.⁵⁶⁵ These vessels have a flat bottom, and the hull shape is determined primarily by the bottom platform.⁵⁶⁶

Table 4-2 Selected Shipwrecks from the Levant

Ship	Date of Construction / Sinking	Part of the Ship		
		Keel	Frames	Hull Planking
Tantura A ⁵⁶⁷	c. 475-525	Pine (<i>Pinus</i>)	varies? ⁵⁶⁸	Aleppo pine (<i>Pinus halapensis</i>)

⁵⁶³ In this region the Byzantine Period is accepted as CE 324–638.

⁵⁶⁴ Kahanov and Royal 2001.

⁵⁶⁵ Pomey et al. 2012, 301.

⁵⁶⁶ Hocker 2004b, 66.

⁵⁶⁷ Wachsmann and Kahanov 1997; Kahanov 2001; Kahanov et al. 2004; Pomey et al. 2012, 259-60.

⁵⁶⁸ No sources mention the specific species.

		Part of the Ship		
Ship	Date of Construction / Sinking	Keel	Frames	Hull Planking
Dor 2001/1 ⁵⁶⁹	c. 494–535	Mediterranean cypress (<i>Cupressus sempervirens</i>)	Turkey oak (<i>Quercus cerris</i>) + 7 other species	Mediterranean cypress (<i>Cupressus sempervirens</i>)
Dor 2006 ⁵⁷⁰	c. 550–615	-	Oak (<i>Quercus</i>) Elm (<i>Ulmus campestris</i>)	Mediterranean cypress (<i>Cupressus sempervirens</i>) Turkish pine (<i>Pinus brutia</i>)
Tantura E ⁵⁷¹	c. 600–900	Mediterranean cypress (<i>Cupressus sempervirens</i>)	<i>Tamarix</i> (X5) ⁵⁷² + 7 other species	Mediterranean cypress (<i>Cupressus sempervirens</i>) Turkish pine (<i>Pinus brutia</i>)
Tantura F ⁵⁷³	c. 650–800	Turkish pine (<i>Pinus brutia</i>) European black pine (<i>Pinus nigra</i>)	<i>Tamarix smyrnensis</i> Turkish pine (<i>Pinus brutia</i>)	Turkish pine (<i>Pinus brutia</i>)
Ma'aghan Mikhael B ⁵⁷⁴	c. 648–740	-	Common walnut (<i>Juglans regia</i>)	Fir (<i>Abies</i>)
Tantura B ⁵⁷⁵	c. 800–825	Oak (<i>Quercus</i>)	Aleppo pine (<i>Pinus halapensis</i>)	Pine (<i>Pinus</i>)

⁵⁶⁹ Mor and Kahanov 2006; Mor 2010; Pomey et al. 2012, 260–2; Kahanov and Mor 2014; Liphshitz 2012a.

⁵⁷⁰ Royal and Kahanov 2000; Kahanov and Royal 2001; Kahanov 2003; Pomey et al. 2012, 262–63; Navri et al. 2014.

⁵⁷¹ Wachsmann and Kahanov 1997; Royal and Kahanov 2000; Pomey et al. 2012, 270–71; Liphshitz 2012a.

⁵⁷² When discussing Tamarisk, the number after “X” represent the number of stamens in the flower. For example, Tamarix X5 is the group of Tamarix species with 5 stamens in the flower; characterized by a diffuse porous wood. See Liphshitz 1998, 54.

⁵⁷³ Barkai and Kahanov 2007; Barkai and Kahanov 2016; Liphshitz 2012a.

⁵⁷⁴ Cohen and Cvikel, 2019.

⁵⁷⁵ Wachsmann et al. 1997; Kahanov 2000; Kahanov et al. 2004; Pomey et al. 2012, 271–2.

Tantura A

Tantura A was dated to c. 475-525 CE based on radiocarbon analysis and the Byzantine pottery associated with the shipwreck.⁵⁷⁶ Although scattered, is hypothesized to be a small coaster around 12 m long, and 4 m wide.⁵⁷⁷ It has flat floor timbers and a sharp turn of the bilge (See Figure 11 for a similar hull shape).⁵⁷⁸ No edge joinery could be found in the ship's hull, and Wachsmann suggests that Tantura A is "the oldest recorded hull in the Mediterranean to have been built in the innovative construction methods", pointing out that this vessel might be the first frame-based vessel discovered so far.⁵⁷⁹ The keel was made of pine (*Pinus*) and a naturally curved Aleppo pine (*Pinus halepensis*) timber that was attached to the northwestern end of the keel has been labelled as an endpost.⁵⁸⁰ Planking was also made of Aleppo pine (*Pinus halepensis*). Liphshitz and Biger have claimed that although it is widespread today, Aleppo pine (*Pinus halepensis*) was not endemic to the Levant in antiquity.⁵⁸¹ They argue that this species is neither prominent in palynological and archaeological data nor is it recorded in written sources.⁵⁸² There is a particularly high percentage of archaeological Aleppo pine (*Pinus halepensis*) finds from the Coastal Plain and the Shephela region of Israel during the Roman-Byzantine Period (17.1%), and since these regions are not suitable for growing pine, Liphshitz and Biger suggest that this increase was due to the importation of Aleppo pine (*Pinus halepensis*) from Lebanon, Cyprus, Turkey or Greece.⁵⁸³ If Tantura A is was not in fact constructed in one of these regions, it is very likely that it was constructed with Aleppo pine (*Pinus halepensis*) timber that was imported to the territory of modern day Israel. However, the fact that it was not recorded in writing does not necessarily eliminate the possibility of Aleppo pine (*Pinus halepensis*) being native to the region, there is always the possibility of a certain tree species to have been ignored by the ancient authors. Aleppo pine (*Pinus halepensis*) on the other hand is slightly shorter and narrower than Turkish pine (*Pinus brutia*) and it is "due to size and shape of most trees and poor quality,

⁵⁷⁶ Sample RT-2162 was dated to cal 330-415 CE with 89% probability, sample RT-2164 was dated to cal 425-530 CE and sample RT-2163 to cal 440-540 CE. See Kahanov and Breistein 1995, 12.

⁵⁷⁷ Pomey et al. 2012, 259-60.

⁵⁷⁸ Pulak 2018, 283.

⁵⁷⁹ Wachsmann 2001, 601.

⁵⁸⁰ Kahanov 2001, 266.

⁵⁸¹ Liphshitz and Biger 2001.

⁵⁸² Liphshitz and Biger 2001, 428-34.

⁵⁸³ Liphshitz and Biger 2001, 423-33.

is of little value as timber, however it grows in hot and dry climate even in *maquis* and garrigues in lower altitudes, making it easier to acquire.”⁵⁸⁴ Therefore, the shipwright might have used Aleppo pine (*Pinus halepensis*) due to local availability and not for the quality of the timber.

Dor 2001/1

Dor 2001/1 (c. 494–53 CE), was dated by ¹⁴C analysis on the short live organic material (such as rope and matting found in the ship) as well as dendrochronological analyses of ceiling timbers (wiggle-matching) to the beginning of the 6th century, with a *terminus post quem* of CE 494–535.⁵⁸⁵ The original dimensions were estimated at 16.9 m long by 5.4 m wide. It does not only date to the same period as Tantura A, but also shows similar construction techniques.⁵⁸⁶ It has been identified the excavators as “among the earliest frame-based shipwrecks” that was found in the Mediterranean so far.⁵⁸⁷ However, Pulak argues that the lack of edge-joinery is in fact indicative of a different shell-based method, “perhaps one using temporary wooden cleats or some other means to secure the planking until the bottom of the hull could be completed and readied for installation of frames.”⁵⁸⁸ The framing system is of floor timbers alternating with paired half frames, and the bottom is again flat with a sharp turn of the bilge, no edge joinery was found.⁵⁸⁹ An estimated 25% of the hull survives, and around nine different species was used in the construction.⁵⁹⁰ Based on her study of the hull remains, Liphshitz states that the main components of construction were Turkish pine (*Pinus brutia*), Mediterranean cypress (*Cupressus sempervirens*), Oriental beech (*Fagus orientalis*), Common elm (*Ulmus campestris*), Kermes oak (*Quercus coccifera*), Sessile oak (*Quercus petraea*), and Turkey oak (*Quercus cerris*). All of these species are of lowland tree coverages, thus would have been easy to acquire. Since these are species native to west – north-western Turkey, the ship might have been made there, and the other two species which are native to Israel, namely Christ's thorn jujube (*Ziziphus spina Christi*) and *Tamarix* (X5), were used when

⁵⁸⁴ Fajon 2017, 703.

⁵⁸⁵ The ¹⁴C dates were between 240 and 540 CE (1 σ), and between 220 and 580 CE (2 σ). Wiggle-matching conducted on the widest ceiling planks provided a *terminus post quem* date of 507–527 CE (1 σ) and 494–535 CE (2 σ). See Kahanov and Mor 2014, 61–2.

⁵⁸⁶ Kahanov and Mor 2006, 2014; Pomey et al. 2012, 260–62.

⁵⁸⁷ Kahanov and Mor 2014, 41.

⁵⁸⁸ Pulak 2018, 281.

⁵⁸⁹ Pulak 2018, 283.

⁵⁹⁰ Kahanov and Mor 2014, 55.

the ship was repaired in this region.⁵⁹¹ Although the ship was possibly in service for relatively short time (perhaps not more than 13 years, based on ¹⁴C wiggle-matching and a Bayesian analytical model by Lorentzen), various repairs were done to the ship's keel, endpost, and planking.⁵⁹² This hypothesis is based on the assumption that the original construction would have been made with native wood, and if the repair pieces are not native to this particular region, they could have been supplied at the port or the region where the repair was made. According to this, a ship that sailed from Western Asia Minor could have been repaired at Dor when it arrived at the port. Another hypothesis, however, would involve the construction of the ship at Dor with the wood that was traded to the region from Western Asia Minor. Both Christ's thorn jujube (*Ziziphus spina Christi*) and *Tamarix* (X5) are shrubs and cannot supply large timbers for shipbuilding, but they can be used as material for small repair pieces or wooden fasteners. Thus, facing a lack of suitable timber, it may have been imported from other regions, such as Cyprus, or Asia Minor coasts to the Levantine coast. If species that are not native to the same region were to be found in the original construction of a ship, then this definitely points to a movement of timber from another region. However, these explanations are based mostly on the modern distribution of these species.

The hull planks of Dor 2001/1, with one exception of Turkish pine (*Pinus brutia*) – a possible repair – was made of Mediterranean cypress (*Cupressus sempervirens*), whereas the ceiling planks were of Turkish pine (*Pinus brutia*). Meanwhile, the frames were of eight different species, the half frames were made of naturally curved, single pieces of hardwood (*Quercus cerris* and *Quercus patraea*).⁵⁹³ The tool marks show that most of the timber was sawn and installed with minimal further working.⁵⁹⁴ This might show that the shipwrights were in a rush to finish the boat, or this was not important and could be neglected to save the time spent on labor. It is interesting that the frames, which are assumed to have preceded planks in the construction sequence by the excavators, were made with mixed tree species, but the preserved hull planks and the ceiling planks were

⁵⁹¹ Liphschitz and Pulak 2007/2008, 76; Liphschitz 2012a, 7-8.

⁵⁹² Lorentzen et al. 2014, 11.

⁵⁹³ Kahanov and Mor 2014, 63.

⁵⁹⁴ Kahanov and Mor 2014, 58-9.

each made of one type of tree. This again might point to the hardship of finding naturally curved timbers in the required angles for the construction of the frames.

Dor 2006

Dor 2006, dating to c. 550-615 CE, is another vessel found in the same region of the Dor lagoon.⁵⁹⁵ The ship is dated by ¹⁴C analysis of sixteen organic samples to CE 220–640 (95%), the pottery assemblage dates to mid-6th and late 8th centuries, and the coins give the *terminus ante quem* of the first quarter of the 7th century.⁵⁹⁶ The shipwreck was in fact much bigger in size compared to the other shipwrecks in the Dor area, and its deep draft was not actually suitable to enter the shallow Tantura Lagoon.⁵⁹⁷ It was a 25 m-long merchantman and was built with a mixed construction technique in which the lower half of the hull was built using shell-based methods while the upper hull was constructed using frame-based techniques.⁵⁹⁸ Compared to the earlier ships found in the lagoon, Dor 2006, with edge joinery, points to a different construction tradition.

Eight tree species were identified in its construction, European ash (*Fraxinus excelsior*), Turkey oak (*Quercus cerris*), Kermes oak (*Quercus coccifera*), Sessile oak (*Quercus petraea*), Common elm (*Ulmus campestris*), Mediterranean cypress (*Cupressus sempervirens*), Turkish pine (*Pinus brutia*), and European black pine (*Pinus nigra*).⁵⁹⁹ The hull was made from softwood, and while more than half of the samples from the hull planks were cypress (*Cupressus sempervirens*); the rest were mostly Turkish pine (*Pinus brutia*), with a few planks of European black pine (*Pinus nigra*). This is probably because these conifers would be able to supply straight logs for the planking. Also, Turkish pine (*Pinus brutia*) and Mediterranean cypress (*Cupressus sempervirens*) are often found together in the forests, thus it is logical to see them used together in one ship.⁶⁰⁰ More than half of the frame samples on the other hand were different varieties of oak, while about one third was elm (*Ulmus campestris*). Liphschitz argues that all these trees are endemic

⁵⁹⁵ Navri et al. 2013.

⁵⁹⁶ Navri et al. 2013, 317.

⁵⁹⁷ Navri et al. 2013, 306.

⁵⁹⁸ Navri et al. 2013, 323.

⁵⁹⁹ Out of 129 samples, 2 European ash (*Fraxinus excelsior*), 31 Turkey oak (*Quercus cerris*), 2 Kermes oak (*Quercus coccifera*), 11 Sessile oak (*Quercus petraea*), 22 Common elm (*Ulmus campestris*), 27 Mediterranean cypress (*Cupressus sempervirens*), 16 Turkish pine (*Pinus brutia*), and 6 European black pine (*Pinus nigra*). It should be noted that the tree species published in Navri et al. 2013 is the updated analysis that was previously published in Liphschitz 2012a with 28 fewer samples.

⁶⁰⁰ Farjon 2017, 660-61.

to western and northwestern Turkey.⁶⁰¹ Navri et al. argue that if the ship was built in the eastern Aegean islands, a native hardwood would have been preferred instead of ash (*Fraxinus excelsior*), as ash is much more prone to decay compared to oaks.⁶⁰² Therefore, the ship might have originated from the coasts of Asia Minor rather than the Aegean islands. Another possibility raised by the excavators is that the ship was built in the Levant with imported timber from Asia Minor.⁶⁰³

Tantura E

The Tantura E shipwreck was first associated with the Abbasid rule in the region based on pottery finds in the hull.⁶⁰⁴ ¹⁴C analysis on nine organic samples (wood and rope) and typology of the amphoras date of the shipwreck between the 7th and 9th centuries CE.⁶⁰⁵ Its original length has been estimated to be around 12-15 m; its hull has no recorded edge joinery, flat floor timbers and a sharp turn at the bilge.⁶⁰⁶ Tantura E was constructed with many short hull planks, combined with many small frame timbers, many of which are likely repairs.⁶⁰⁷ As short planks would not be desirable, this might point to a lack of available timber at the construction site if these planks are indeed not repairs. Bricks found in the shipwreck were provenanced to Egypt using neutron activation analysis (NAA); if this was where the ship was constructed, a lack of longer, higher-quality timbers in the hull might be expected.⁶⁰⁸ The tree species used in construction are also the same as in the earlier vessels: the hull planks were identified as Turkish pine (*Pinus brutia*) and Mediterranean cypress (*Cupressus sempervirens*) meanwhile frames were again made from various tree species, *Tamarix* [X4, X5], different oak variants, Kermes oak (*Quercus coccifera*) and Turkey oak (*Quercus cerris*), as well as elm (*Ulmus campestris*) and European ash (*Fraxinus excelsior*).⁶⁰⁹ Again, more diversity can be identified in the framing compared to the hull planking in respect to the choices in wood types. All of these trees are native to west-northwest Turkey with the exception of tamarisk, which has led Liphshitz to conclude that it was installed to the ship as repair

⁶⁰¹ Liphshitz 2012a, 4.

⁶⁰² Navri et al. 2013, 316; Akkemik 2015, 165.

⁶⁰³ Navri, Kahanov and Cvikel 2013, 316

⁶⁰⁴ Royal and Kahanov 2000; Pomey et al. 2012, 270–71.

⁶⁰⁵ Israeli and Kahanov 2014, 383.

⁶⁰⁶ Pulak 2018, 283.

⁶⁰⁷ Israeli and Kahanov 2014, 385.

⁶⁰⁸ Israeli and Kahanov 2014, 386.

⁶⁰⁹ Liphshitz 2012a, 6.

pieces.⁶¹⁰ The excavators, on the other hand, suggest that the ship could also have been constructed in Levant or Egypt with imported wood.⁶¹¹

Tantura F

Another shipwreck with a flat bottom that was recovered in the Dor lagoon is Tantura F.⁶¹² The typology of the pottery found on the ship dates it to between the mid-7th and the end of the 8th century, from the establishment of the Umayyad rule to later Islamic domination.⁶¹³ The ship, which was estimated to be 15 m long and 5 m wide, with a flat floor and a round turn of the bilge, and without any edge joinery.⁶¹⁴ The hull was made from two species, Turkish pine (*Pinus brutia*) and *Tamarix smyrnensis*.⁶¹⁵ These two species are both native to two different regions of Asia Minor, Izmir and Antalya.⁶¹⁶ Therefore, if the vessel was built with local wood, one of these two regions could be the likely location of a shipyard.

Barkai and Kahanov note the use of Turkish pine (*Pinus brutia*) and *Tamarix smyrnensis* in different parts of the ship; Turkish pine (*Pinus brutia*) was used for the keel, the transitional timbers (curved keel timbers), the planks, the mast-step and crutches, the sister-keelsons, the stringers and the straight and middle frames.⁶¹⁷ *Tamarix smyrnensis*, on the other hand, was used for the ‘central longitudinal timbers’, slightly curved longitudinal timbers at the ends of the ship fastened over the frames, with a presumed function similar to a keelson; the short, angular frames and all the futtocks, and the triangular element in the bow.⁶¹⁸ As can be seen, the straight parts were made with Turkish pine (*Pinus brutia*), which often grows straight to lengths around 30 m, allowing these planks to be extracted. Meanwhile, the tamarisks’ own curvature was compatible with the curved components and thus did not require much additional shaping work to be done to the wood. As Barkai and Kahanov also emphasize, compared to Dor 2001/1, Dor 2006 and Tantura E, a much smaller variety of timber species were used in the

⁶¹⁰ Liphschitz 2012a, 5.

⁶¹¹ Israeli and Kahanov 2014, 379.

⁶¹² Barkai 2009, 33-9.

⁶¹³ Barkai and Kahanov 2016, 21.

⁶¹⁴ Pomey et al. 2012, 269–70; Pulak 2018, 283.

⁶¹⁵ Liphschitz 2012a, 8.

⁶¹⁶ Liphschitz and Pulak 2007/2008, 76.

⁶¹⁷ Barkai and Kahanov 2016, 17.

⁶¹⁸ Barkai and Kahanov 2016, 17.

construction.⁶¹⁹ In regard to the carpentry of the ship, the shipwright seems to have focused on the functional needs of the components as some of the pieces show little evidence of additional shaping.⁶²⁰

Ma'aghan Mikhael B

One of the most recent finds from the region is the Ma'aghan Mikhael B shipwreck, dating to c. 650-885 CE, the Late Byzantine and early Islamic periods in the region.⁶²¹ The radiocarbon analysis narrows the dating of the ship to cal 648–740 CE with 95.4% probability.⁶²² It is estimated to be around 25 m long, and identified as a merchantman carrying cargo which originated from various locations such as Egypt and Asia Minor.⁶²³ The wood used in its construction is an exception in the eastern Mediterranean in this period: walnut (*Juglans regia*) has rarely been documented, at least from the Byzantine era shipwrecks from the Eastern Mediterranean, and it is most extensively used in furniture making.⁶²⁴ Two examples of the use of this species in 1st millennium CE shipwrecks can be pointed out. It is found in some ships excavated from the Theodosian Harbor, where Akkemik and Kocabaş suggest it was used primarily for repairs.⁶²⁵ In the analysis of Napoli C shipwreck, it was found that several repairs and framing was made of walnut (*Juglans regia*), and this was interpreted as local availability of the species.⁶²⁶ In fact, the pollen analysis showed that there was a significant presence of *Juglans regia* throughout the investigated period in the environs of the site.⁶²⁷ This then might show that the repair pieces were not specifically sought after but were made with the wood that was available in the general area.

In fact, this tree is a part of arboriculture practices as it was often cultivated for its nuts in different areas of the empire. In the context of the harbor of Neapolis in Italy for example, it was suggested that it was cultivated for both food and timber.⁶²⁸ The pollen data from Sagalassos and Beyşehir also indicates that its cultivation was widespread in

⁶¹⁹ Barkai and Kahanov 2016, 17.

⁶²⁰ Barkai and Kahanov 2016, 15.

⁶²¹ Cohen and Cvikel 2019.

⁶²² Cohen and Cvikel 2019, 199.

⁶²³ Cohen and Cvikel 2019, 204.

⁶²⁴ Akkemik 2015, 167.

⁶²⁵ Akkemik and Kocabaş 2014, 324.

⁶²⁶ Allevato et al. 2009, 39.

⁶²⁷ Allevato et al. 2009, 39.

⁶²⁸ Allevato et al. 2016, 603-13.

Asia Minor as well.⁶²⁹ This might also lead us to speculate that walnut was being cultivated, cut and stored for seasoning, thus there might have been stores for wood where shipwrights when needed could use. However, 82% of the samples from the Ma'agan Mikhael B hull are walnut (*Juglans regia*), which indicates it was occasionally a major source of shipbuilding timber for vessels and not just a timber type used in repairs.⁶³⁰ The processing of walnut is very easy and “the quality of the results is rather remarkable”, and it has a flexible structure.”⁶³¹ The framing timbers are also walnut (*Juglans regia*) with two exceptions, one holly/holm oak (*Quercus ilex*) and one fir (*Abies*), which the excavators so far has identified as repair pieces.⁶³² The planking, on the other hand, was made of fir (*Abies*). Overall, the wood used the construction of the Ma'agan Mikhael B has been described as of good quality.⁶³³

Tantura B

Tantura B, on the other hand, dates to the early 9th century, with a hull estimated around 18-23 m in length it is flat bottomed lacking edge joinery.⁶³⁴ The keel of the ship was made of oak (*Quercus*), whereas the keelson and a plank was identified as pine (*Pinus*). Several other members, such as stringers, around thirty frames, a garboard and several ceiling planks were found to be Aleppo pine (*Pinus halepensis*).⁶³⁵ Therefore, the ship was mainly a combination of oak and pine, very typical in the Mediterranean. Dendrochronological samples taken from the three of the widest pine planks proved to be problematic. Pine had to be cross dated to the Aegean Oak Master Chronology, and as Kuniholm has reported, the closest dates were either CE 801 or 829, or neither.⁶³⁶ This shows that although dendrochronology is a reliable method, it has limitations based on the number and quality of the available samples. The radiocarbon sample on the other hand yielded a date of 680-850 CE.⁶³⁷ These results, combined with the ceramic evidence

⁶²⁹ Vermoere et al. 2003, 171; Eastwood et al. 1998, 74.

⁶³⁰ Cohen and Cvikel 2019, 199.

⁶³¹ Giachi et al. 2003, 279; Akkemik 2015, 16.

⁶³² Cohen and Cvikel 2019, 198.

⁶³³ Cohen and Cvikel 2019, 203.

⁶³⁴ Pomey et al. 2012, 271–2.

⁶³⁵ Wachsmann, Kahanov and Hall 1997, 7; Pomey et al. 2012, 271.

⁶³⁶ Wachsmann, Kahanov and Hall 1997, 11.

⁶³⁷ Wachsmann, Kahanov and Hall 1997, 11.

and the dendrochronological analysis, points to an early 9th century date for the shipwreck.

Considering the roundel object (possibly a spool) which had Kufic inscriptions on it, “*aṭher-i ḥuqmullah*”, meaning “Allah has the purest judgement” and an Abbasid period oil lamp found in the context of the shipwreck, Tantura B has been identified as an “Islamic” shipwreck.⁶³⁸ Kahanov argued that it could have been either “a merchantman plying the Levantine coast, capable of entering rivers or estuaries; or a support vessel operating in the Arab fleet”.⁶³⁹ When the timber types are considered, both options would be plausible, and in fact are in line with Theophrastus’ recommendations (Theophr. *Hist. pl.* V.vii.1). The timber that are suitable for the performance requirements of war ships will be discussed; however, an oak keel that is durable combined with pine planking that would give the vessel flexibility and lightness would be desirable for a warship. Khalilieh argues that the ship is an ‘*ushārī*’.⁶⁴⁰ Agius describes an ‘*ushārī*’ as a “domed-cabin gondola” and was used on the Nile.⁶⁴¹ Khalilieh points to the references, where it has been used to sail on the trunk routes connecting Egypt with North Africa, Sicily, and the Levant.⁶⁴² It may have been a dual-use vessel, which sailed on rivers, along the coasts, and on the high seas, using both oars and sails.⁶⁴³ Whether it is a military or a cargo vessel, the timber that was used in its construction was not different from the other vessels found in the region. Even if it was made by a Byzantine or Islamic shipwright, the preferences of timber were determined by the requirements of the vessel and the material available in the region or in a particular trade network.

Conclusion

This assemblage presents interesting results. To start with, Tantura A, Dor 2001/1, Tantura E, Tantura F and Tantura B share many specific construction techniques: they all lack edge joinery and have a flat bottom with a framing system of floor timbers alternating with paired half frames, with futtocks and top timbers. Similar features can be observed separately in various shipwrecks, such as YK 17 (652-870), which lacks edge joinery, as

⁶³⁸ Wachsmann et al. 1997, 10.

⁶³⁹ Kahanov et al. 2004, 126.

⁶⁴⁰ Khalilieh 2005, 319.

⁶⁴¹ Agius 2008, 301-03.

⁶⁴² Khalilieh 2005, 319.

⁶⁴³ Khalilieh 2005, 319.

the earliest example for this type in the Yenikapı assemblage.⁶⁴⁴ If the depth of the lagoon was similar to today's, entrance would have required a flat floored, shallow draft construction. This does not necessarily mean they were constructed at Dor. If Liphshitz' arguments are accepted, then most of these ships would have been constructed in the western coast of Asia Minor. A possibility is the exchange and movement of timber, and the importation of the wood that is native to Western Asia Minor due to the lack of suitable shipbuilding timber in the Dor region. It is important however to look at these cases individually, as some wood used in construction of the ships could have been imported from other regions, represented as reused timber from older ships that were built elsewhere, or repairs made on ships while visiting foreign ports.⁶⁴⁵

4.3.3 *Yenikapı*

At the Yenikapı excavations lasting from 2004 to 2013, which revealed the Theodosian Harbor of Constantinople, an assemblage of almost 37 Byzantine ships have been recovered, variously dating between the 5th and the 11th centuries CE. The Theodosian Harbor was probably constructed during the reign of Theodosius I (r. 379–395 CE) and was located on the Marmara shore of Constantinople. It was indeed the main harbor for commercial activities in 4th – 7th centuries CE, Magdalino points out that no commercial activity at the Harbor of Theodosius is recorded in the medieval period in the written sources.⁶⁴⁶ However, it has been shown with the archaeological evidence that the harbor was in use in later periods as well for small- and medium-sized ships, until at least the late 10th or early 11th century CE.⁶⁴⁷

From the Theodosian Harbor, two types of vessels have been excavated: roundships which may have been merchant ships, fishing boats, and local coasters; and longships, which were propelled with both sails and oars and were used as warships.⁶⁴⁸ In addition to these, there were merchant galleys known from the Roman Imperial Period as well,

⁶⁴⁴ Pulak 2018, 284.

⁶⁴⁵ Liphshitz and Pulak 2007/08, 73.

⁶⁴⁶ Magdalino 2007, xii.

⁶⁴⁷ Pulak et al. 2015, 39; Magdalino 2013, 15.

⁶⁴⁸ Pulak et al. 2015, 62. Longships were originally Norse or Viking galleys, used mainly for raiding and for war purposes approximately between the years 600–1000 CE, and the term denotes a slender hull, with a length to beam ratio of approximately 1:7. Roundships on the other hand have a length to beam ratio of approximately 1:3. See Unger 1981, 236. These terms were adapted from Unger for a basic classification of Mediterranean shipwrecks.

which were often used for dispatches that required rapid transport; depending mainly on oars, however there is no direct evidence for such ships from the Theodosian Harbor.⁶⁴⁹ They were wider than the longships, with a length to beam ratio of 1:5.⁶⁵⁰

The preservation of the ships from Yenikapı is much higher than the previously analyzed shipwrecks because, they were rapidly buried in anaerobic waterlogged sediments after sinking.⁶⁵¹ The ships recovered from the seabed in the Mediterranean such as Serçe Limanı or Yassıada were exposed to the sea for a period and therefore decayed further, while the shipwrecks at the Theodosian Harbor were protected by marine sand and the silt of the Lykos River, which eventually filled the harbor itself.⁶⁵²

The various merchant ships recovered from the seabed in the Mediterranean have been preserved mainly by the ballast or non-perishable cargo (glass, stone, bricks, metal ingots) they were carrying, usually amphoras. However, warships typically carried no heavy cargo to force them to the bottom, a damaged warship generally float away in pieces at the surface. However, they could also be towed away by the victor for salvage, as galleys were highly valuable instruments of war for their time, especially with the rams attached. Another possibility for a galley was to simply disappear on the seabed without a protective non-perishable layer on top.⁶⁵³ One type of archaeological evidence for ancient warships are preserved bronze rams, metal attachments to the prow of ships. The Athlit ram was found on the coast of Israel in 1980 and deriving from the iconography, it is believed to be from either Ptolemy V Epiphanes (r.204-180 BCE) or Ptolemy VI Philometor's (r. 180-145 BCE) navy.⁶⁵⁴ There were in fact remains of wood inside this ram: stem and ramming timber was made from cedar, the keel and the planks were of pine, the edge-fastenings were made of oak, and the rest of elm.⁶⁵⁵ In Sicily, more than fifteen ship rams have been recovered at Egadi, on the supposed battle site of the Aegates Islands in the First Punic War (264-241 BCE).⁶⁵⁶ These rams belonged to both the

⁶⁴⁹ Casson 1995, 157.

⁶⁵⁰ Casson 1995, 158.

⁶⁵¹ Pulak et al. 2015, 42.

⁶⁵² Kocabaş 2012a, 107.

⁶⁵³ Carlson 2011, 395; Pulak et al. 2015, 62; Pulak 2018, 262. The rams were spolia during the Roman period. See Murray and Petsas 1988 for the campsite monument of Octavian commemorating his victory at the Battle of Actium.

⁶⁵⁴ Murray 1991, 66.

⁶⁵⁵ Steffy 1991, 17.

⁶⁵⁶ Tusa and Royal 2012.

Romans and Carthaginians, which is identifiable from the Latin and Punic inscriptions of prayers incised on the rams; however, the ships themselves were not preserved.⁶⁵⁷ The use of rams however fell out of use in the late Roman and Byzantine periods.⁶⁵⁸

Outside the Mediterranean, several river patrol boats, which would be used for troop and supply transportation belonging to the European river fleets of the Roman Imperial Period were found. Two vessels from Oberstimm, found close to a Roman fort in the Upper Danube, date to late 1st and early 2nd century CE. They are made with shell-based constructions with mortise-and-tenon joinery, while the planking of the vessels are made with pine, the frames and the keel, as well as the edge-joinery are of oak and other hardwoods.⁶⁵⁹ On the other hand, five late Roman (late 3rd – 4th century CE) boats excavated in the city of Mainz did not have mortise-and-tenon joinery, and with the exception of the beech ceilings of Ship 4, were made exclusively with oak.⁶⁶⁰ However, these were not seagoing warships.

The silting of the Theodosian Harbor therefore also allowed for warships to be preserved. It has been proposed that a storm was the likely reason behind rapid sinking into the harbor floor, as well as other roundships that were found without a cargo; however some of them might have been fell out of use, salvaged and abandoned as well.⁶⁶¹ The six warship wrecks recovered at Yenikapı is an exceptional source of evidence for naval construction in the ancient Mediterranean between 7th and 11th centuries, as they are the first early medieval galleys ever discovered in the region.⁶⁶² These ships are structurally different than the roundships, and thus the timber that was used in their construction varied as well. Therefore, the Yenikapı assemblage will be analyzed in two groups, longships and roundships, and will later be compared in order to understand how timber choices change for different structural problems.

⁶⁵⁷ Aside from these, several other rams were found in the Mediterranean that include the Bremerhaven Ram, Piraeus Ram, Acqualadroni Ram which are testimonies to warships. See Murray 1991, 75; Steinhauer 1998, 30; Buccellato and Tusa 2013.

⁶⁵⁸ See for example van Doornick 1993; Pryor and Jeffreys 2006, 143.

⁶⁵⁹ Bockius 2002, 151-54.

⁶⁶⁰ Höckmann 1993, 126.

⁶⁶¹ Pulak et al. 2015, 46; Kocabaş 2015.

⁶⁶² Pulak et al. 2015, 42.

Longships

The six warships dating tentatively between c. 680 – 1000 CE have been excavated.⁶⁶³ They were assumed to be around 30 meters in length, with one bank of oars; and compared to the *dromon* reconstructions which have two banks of oars and are often at least 31-32 m, they are smaller.⁶⁶⁴ They also have one level of oars. Pulak et al. argue that these warships resemble what the 9th – 10th century Byzantine authors refer as *galeai*.⁶⁶⁵ In Constitution 19 of the *Taktika* of Leo VI, on paragraph 10, it suggests that “In addition, you will outfit smaller *dromons*, very fast ones, like those called *γαλέαι* (*galeai*) or *μονήρεις* (*monoreis*), swift and light, which you can use for scouting and other operations requiring speed” (*Taktika* 19.10). The name *monoreis* terminologically illustrates the structural features of this type of ship, as *monoreis* is used for vessels that were rowed with a single bank of oars.⁶⁶⁶ Another reference to the *galeai*, showing that one of the roles of this type of ship was scouting, is from *De cerimoniis*;

Note that the *strategos* of the Kibyrrhaiotai and the *katepano* of the Mardaites of Attaleia gave undertakings: the *strategos* that he would get ready two *chelandia* from units of the *tourmarchai*, and the *katepano* of the Mardaites that he would get ready galleys, and during the month of March they would send them to Syria to bring back a response and reliable report concerning everything being planned and done there. (*De Cer. Book II, Chapter 44*, R657)

The ships of this type that were found at Yenikapı were YK 2 (c.680-980 CE), YK 13 (690-890 CE), YK 4 (c. 710-1020 CE), YK 16 (c. 720-890 CE), YK 25 (c. 900-1000 CE), YK 36 (c. 900-1000 CE). Two of these ships, YK 2 and YK 4, are being studied by the team from the Institute of Nautical Archaeology, while YK 13, YK 16, YK 25 and YK 36 are being studied by Istanbul University.⁶⁶⁷ In this section, the timber choices for galleys will be discussed on the basis of the differences between parts of ships, as well as

⁶⁶³ This range is wide due to the ¹⁴C results, however from the pottery finds it can be said that most of them date to the later periods in this range.

⁶⁶⁴ Pryor 2002, 40-41.

⁶⁶⁵ Pulak et al. 2015, 62.

⁶⁶⁶ Pryor and Jeffreys 2006, 190.

⁶⁶⁷ Pulak et al. 2015; Kocabaş 2015.

in a chronological comparison. In addition, two ships, YK 2 and YK 4 will be discussed comparatively. These ships were chosen due to the fact that their dendroarchaeological (wood identification) analysis was done by the same laboratory, one of them sank as a new ship and the other one was in use for a while, the differences can reveal about the shipwrights initial preferences compared to the repair pieces.⁶⁶⁸

Galleys suffer from different structural problems compared to roundships due to their higher length to beam ratio, which makes them very slender. For example, the length to beam ratio for the galley YK 2 is estimated to be around 7:1, within the range for warships, while for Tantura F, a typical Roman-Byzantine merchant ship, it is 3:1. During the Roman and Byzantine periods, the merchant ships often followed these measurements. For all wooden ships, there is the danger of the hull hogging and sagging. Hogging is when the keel of the ship curves upwards from the middle, resulting in the two extremes of the ship to move closer to the water, and sagging is when the opposite happens, the middle of the keel bends down.⁶⁶⁹ Longships, because of their length to beam ratio, are more susceptible for hogging and sagging, as the longitudinal stress put on the hull and the keel with the movement in the sea could damage the integrity of the ship.⁶⁷⁰ These affect all wooden ships, but the long and narrow hulls of galleys are more prone to having this problem. Pulak argues that in order to reduce this stress, a V shaped, or wine-glass-shaped hull was necessary instead of a flatter bottom, and thus floor timbers alternating with paired half-frames were used.⁶⁷¹

Another solution to the issue, however, was to decrease the points on the hull that would be the most affected by the stress. These points include the scarf ends, where the shorter, vertical sides of the planks would be attached to each other, often with diagonal or 'S' scarf joints, and the plank seams, where the planks were connected horizontally as they were attached on top of each other (Figure 12).⁶⁷²

⁶⁶⁸ Liphschitz and Pulak 2009, 168-9.

⁶⁶⁹ Steffy 1994, 273, 279.

⁶⁷⁰ See Steffy 1994, 273, 279 for the glossary descriptions.

⁶⁷¹ Steffy 2004, 158; Pulak 2018, 275.

⁶⁷² S-scarves would allow the shipbuilder to install planks without the need of frames.

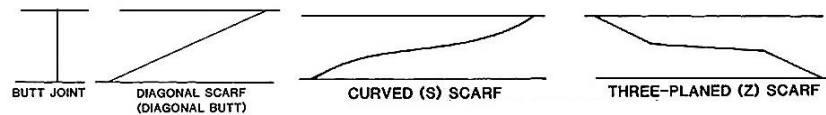


Figure 12 Different scarf types commonly seen on Roman and Byzantine ships. After Steffy 1994, 292.

Pulak theorizes that one simple way to minimize the weak spots that are created at these locations is to use longer and broader pieces of wood.⁶⁷³ Indeed, it was observed that the planks that were cut for the hulls of these ships were larger and longer compared to the planks of the roundships from the site.⁶⁷⁴ Another consideration for building galleys were the weight of the hull. These vessels would be sailed when possible, and during the battle, moving against the current or during maneuvers they would be rowed. To make it easier for the oarsman to row at a significant speed and maneuver, the ship had to be kept as light as possible.⁶⁷⁵ As it will be shown, the timber choices were affected to provide suitable planks for these specific concerns for warship construction.

Table 4-3 Longships Excavated from the Theodosian Harbor

		Part of the Ship		
Ship	Dating	Keel	Frames	Planking
YK 2 ⁶⁷⁶	c. 680 –980	—	81% <i>Platanus orientalis</i> 19% <i>Ulmus campestris</i>	100% <i>Pinus nigra</i>
YK 13 ⁶⁷⁷	c. 690 –890	50% <i>Platanus orientalis</i> 50% <i>Quercus</i>	54.8% <i>Platanus orientalis</i> 37% <i>Ulmus</i> + <i>Quercus</i> , <i>Juglans</i> , <i>Carpinus</i> , <i>Abies</i>	100% <i>Pinus nigra</i>

⁶⁷³ Pulak 2018, 277. In later galleys, different methods were used. Around 13th century Italy for example, longitudinal timbers at the level of the benches called *corsia* were used to strengthen the hull and prevent sagging. See Kleinhenz 2004, 1029.

⁶⁷⁴ Pulak et al. 2015, 68.

⁶⁷⁵ Steffy 1994, 11.

⁶⁷⁶ Radiocarbon dating. See Pulak et al. 2015, 62–4. Sample TR5/240 dated to cal 770–940 CE with 68.2% and cal 690–980 CE with 95.4% probability. Sample TR5/249 dated to cal 770–890 CE with 68.2% and cal 680–970 CE with 95.4% probability. Kocabaş 2008; Kocabaş 2012; Akkemik 2015; Akkemik and Kocabaş 2013; Akkemik and Kocabaş 2014; Pulak et al. 2015; Pomey et al. 2012, 279–85; Liphshitz 2014a; Liphshitz and Pulak. 2009, Pulak 2018.

⁶⁷⁷ Radiocarbon dating. See Kocabaş 2015, 17. Sample OxA-23834 dated to cal CE 690–881 with 95.4% and cal CE 762–881 with 64.7% probability. Sample OxA-23835 dated to cal CE 714–890 with 98.4% and cal CE 767–890 with 87.0% probability. Kocabaş 2008; Kocabaş 2012; Akkemik 2015; Akkemik and Kocabaş 2013; Akkemik and Kocabaş 2014; Pomey et al. 2012, 279–85.

		Part of the Ship		
Ship	Dating	Keel	Frames	Planking
YK 4 ⁶⁷⁸	c. 710 –1020	100% <i>Platanus orientalis</i>	84.5 % <i>Platanus orientalis</i> + <i>Acer pseudoplatanus</i> , <i>Fraxinus excelsior</i> , <i>Quercus cerris</i> , <i>Tamarix</i> (X5), <i>Pinus nigra</i>	100% <i>Pinus nigra</i>
YK 16 ⁶⁷⁹	c. 720 –890	—	48% <i>Platanus orientalis</i> 46.5% <i>Ulmus</i> + <i>Abies</i> , <i>Pinus nigra</i> , <i>Pinus</i>	92.3% <i>Pinus nigra</i> 7.6% <i>Abies</i>
YK 25 ⁶⁸⁰	c. 900 –1000	—	98% <i>Platanus orientalis</i> 2% <i>Ulmus</i>	54% <i>Pinus nigra</i> 46% <i>Cedrus libani</i>
YK 36 ⁶⁸¹	c. 900 –1000	100% <i>Platanus orientalis</i>	52% <i>Platanus orientalis</i> 28% <i>Quercus</i> 8% <i>Pinus nigra</i> + <i>Castanea sativa</i> , <i>Pinus pinea</i>	61.7% <i>Castanea sativa</i> 17.6% <i>Pinus nigra</i> 11.7% <i>Quercus</i> + <i>Pinus pinea</i> , <i>Platanus orientalis</i>

Table 4-3 illustrates the wood types used in the keels (if recovered), frames and planking of the galleys YK 2, YK 3, YK 4 YK 16, YK 25 and YK 36. The percentages that are given are the percentage of the presence of that specific species within the samples that were taken. For example, 44 samples were taken from YK 4 planking components, while for YK 13 this number is 19.⁶⁸² Still, the table lays out the main tree types used for the specific components of the ships. It can be seen that the keels that were recovered were made from Oriental plane (*Platanus orientalis*), and this does not change from the 7th to the 11th centuries. Oriental plane is in fact not a very common shipbuilding

⁶⁷⁸ Radiocarbon dating. See Pulak et al. 2015, 64-8. Sample TR7/745 dated to cal 780-970 CE with 68.2% and 710-990 CE with 95.4% probability. Kocabaş 2008; Kocabaş 2012; Akkemik 2015; Akkemik and Kocabaş 2013; Akkemik and Kocabaş 2014; Pulak et al. 2015; Pomey et al. 2012, 279–85; Liphshitz 2014a; Liphshitz and Pulak. 2009; Pulak 2018.

⁶⁷⁹ Radiocarbon dating. See Kocabaş 2015, 17. Sample OxA-23846 dated to cal CE 721–890 with 95.4% and cal CE 770–890 with 90.8% probability. Sample OxA-23847 dated to cal CE 720–889 with 95.4% and cal CE 769–889 with 90.1% probability. Sample OxA-23848 dated to cal CE 725–934 with 95.4% and cal CE 771–895 with 93.1% probability. Kocabaş 2008; Kocabaş 2012; Akkemik 2015; Akkemik and Kocabaş 2013; Akkemik and Kocabaş 2014; Pomey et al. 2012, 279–85; Liphshitz 2014a.

⁶⁸⁰ Dated based on stratigraphic context. See Kocabaş 2015, 17. Kocabaş 2008; Kocabaş 2012; Akkemik 2015; Akkemik and Kocabaş 2013; Akkemik and Kocabaş 2014; Pomey et al. 2012, 279–85; Liphshitz 2014a.

⁶⁸¹ Kocabaş 2008; Kocabaş 2012; Akkemik 2015; Akkemik and Kocabaş 2013; Akkemik and Kocabaş 2014; Pomey et al. 2012, 279–85; Liphshitz 2014a.

⁶⁸² Liphshitz and Pulak 2009, 169; Akkemik 2015, 48-53.

timber.⁶⁸³ One reason might be the probability of galleys being beached for supplying provisions from land, and thus their keels has to endure hauling onto the shore.⁶⁸⁴ Liphshitz argues that the reason why the ship builders preferred Oriental plane above other hardwoods such as oak (which in fact is a small component of YK 13's keel) is because plane is much lighter.⁶⁸⁵ The galleys had to be as light as possible to be rowed with ease and therefore a light hardwood was preferred for their keels.

The effort to keep the ship light is also apparent in the high percentage of Oriental plane (*Platanus orientalis*) that was used for the framing components. It can be seen from Table 4-3 that for all the galleys, Oriental plane (*Platanus orientalis*) is the highest percentage in the samples from the frames. It can be argued that other wood types were also used in the framing (of which some of them are in fact repairs); it must be pointed out that Oriental plane (*Platanus orientalis*) was only used for the galleys at Yenikapı and it was not found frequently in the roundships except for the keels of YK 3 and YK 19 as well as the framing of YK 3.⁶⁸⁶ This shows that the tree was specifically selected for the warships, although sometimes used alongside other tree species. On the other hand, it must be remembered that Theophrastus wrote "Plane wood is the worst because it rots quickly." (Theophr. Hist. pl. V.vii.1-3). It also is not a common shipbuilding timber today.⁶⁸⁷ There are several reasons why it might have been preferred for the galleys.

Pulak et al. also observe that the frames themselves with cross-sections of approximately 60 mm had relatively small diameters, which was typical for galleys construction in the Mediterranean for later periods too.⁶⁸⁸ It has a spreading crown, which produces different curvatures, therefore Oriental plane (*Platanus orientalis*) might have been suitable as compass timbers. It can be assumed that for the keels and the frames, the preference of this wood type was directly related to its contribution to the functions of the warships, it is a light but somewhat durable wood, therefore the ship can be rowed faster but can also endure the conditions of the open sea.

⁶⁸³ Liphshitz 2014, 85.

⁶⁸⁴ This very common assumption however has recently been questioned, see Votruba 2017, 14-7.

⁶⁸⁵ Liphshitz 2014, 85; Akkemik and Kocabaş 2013, 39.

⁶⁸⁶ Akkemik 2015, 183.

⁶⁸⁷ Akkemik 2015, 171.

⁶⁸⁸ Pulak et al. 2015, 63.

Another tree species that was mainly used for the galleys is European black pine (*Pinus nigra*), it was the main construction material for the hull planking for almost each galley, except for YK 34. Pulak et al. state that the planks that were used for the galleys at Yenikapı were larger in size and better quality compared to the roundships.⁶⁸⁹ On average, the planks of YK 2 were 25–28 mm in thickness and 300–350 mm in width; and the original lengths, known for just three of the planks, ranged from 6.97 to 10 m, for YK 4, planks up to 11 m were found.⁶⁹⁰ On the roundships however this was lower, the planks of YK 14 were in average 0.77 to 6.74m, 134 mm wide, and the timber species that were used were different.⁶⁹¹ The size of the planks were preferred to be broad and long for the reasons discussed before, to minimize the weak spots on the hull. European black pine (*Pinus nigra*) is suitable for this purpose, since it has a tall and wide trunk (growing up to 40 m in length and 1.5 m diameter at breast height), so that bigger planks could be obtained.⁶⁹² It is also a softwood, which makes it lighter than oak (the common tree species for the planking of the roundships), more flexible, resistant to shocks and rots due to its resinous nature, and thus more suitable for warships.⁶⁹³ Davies points out that in Marmara region the natural range of European black pine (*Pinus nigra*) once stretched as dense woodlands from the Belgrade Forest on the Bosphorus southeastward to Iznik.⁶⁹⁴ The treenails on the other hand were made with Turkey oak (*Quercus cerris*), some from branches, which are both strong and flexible because they are not heartwood.⁶⁹⁵

The choices that the shipwrights have made regarding the selection of the tree species is not completely dependent on the type of the ship. Understanding the cognitive process behind the selection of timbers during repairs might reveal more about the nature of this process. In order to understand this, the two warships YK 2 and YK 4 will be compared. As mentioned previously, their dendroarchaeological (wood identification) analysis was done at the same laboratory, the team who completed the documentation was the same for both ships, and there are no any differences in data presentation.⁶⁹⁶ Pulak, et al. conclude that YK 2 and YK 4 would have been around 30 m in length and 4 m in breadth,

⁶⁸⁹ Pulak et al. 2015, 63.

⁶⁹⁰ Pulak et al. 2015, 63.

⁶⁹¹ Jones 2017, 261.

⁶⁹² Liphschitz and Pulak 2009, 171.

⁶⁹³ Pulak et al. 2015, 68.

⁶⁹⁴ Davis 1965, 74.

⁶⁹⁵ Pulak 2018, 277.

⁶⁹⁶ Liphschitz and Pulak 2009, 168-69; Liphschitz 2014, 84-5; Pulak et al. 2015, 62-8.

which could accommodate 25 oarsmen on each side of the ship, each on a single oar.⁶⁹⁷ Pulak also observes that these two galleys (and probably the other four galleys that were excavated) are very similar in construction techniques, the design and construction are done to strict, nearly uniform standards and the material is of higher quality, which overall might point to construction in an imperial shipyard, or contracted shipwrights working to specific standards.⁶⁹⁸

Both YK 2 and YK 4 date to the 8th – 10th centuries CE, however their time spent in the sea is drastically different.⁶⁹⁹ There are no clear indications of repairs to YK 2's hull, which suggests that it was fairly a new ship when it sank.⁷⁰⁰ YK 4, on the other hand, was repaired extensively.⁷⁰¹ In YK 2, only two different species were used for the (original) framing: Oriental plane (*Platanus orientalis*) was used for the majority, while Common elm (*Ulmus campestris*) was used for the rest. It seems as if these two species were used interchangeably for frames in the hull. In YK 4's hull, about six different tree species were used for the framing.⁷⁰² Although the majority was again Oriental plane (*Platanus orientalis*), Sycamore maple (*Acer pseudoplatanus*), European ash (*Fraxinus excelsior*), Turkey oak (*Quercus cerris*), *Tamarix* (X5), and European black pine (*Pinus nigra*) was also used.⁷⁰³ However, most of the species other than Oriental Plane (*Platanus orientalis*) were identifiable as repairs. The repair pieces are installed next to the original frames, thus breaking up a regular framing pattern of alternating floors and paired half-frames. Another indication for the repairs is that the original frames were attached with treenails made exclusively from Turkey oak (*Quercus cerris*), while the later additions had a variety of wood species used as treenails, Oriental plane (*Platanus orientalis*), European ash (*Fraxinus excelsior*), Sycamore maple (*Acer pseudoplatanus*), and European black pine (*Pinus nigra*).⁷⁰⁴ The fasteners of these new frames were also made from the material of the frames itself. Thus, in the initial construction, the original frames from Oriental plane (*Platanus orientalis*) were attached with treenails of Turkey oak (*Quercus cerris*) meanwhile during the repairs, it is possible that only the available material was used. It

⁶⁹⁷ Pulak et al. 2015, 62.

⁶⁹⁸ Pulak 2018, 264.

⁶⁹⁹ Pulak 2018, 263-64.

⁷⁰⁰ Pulak, et al.2015, 62.

⁷⁰¹ Pulak, et al.2015, 64.

⁷⁰² Liphshitz and Pulak 2009, 169.

⁷⁰³ Liphshitz and Pulak 2009, 169.

⁷⁰⁴ Liphshitz and Pulak 2009, 169.

was also observed that most of the repairs that were done in YK 4's framing -which are these different tree species- were located amidships as well as the bow (where the mast would have been located. Since they are smaller than a *dromon*, they likely had one mast amidships.). Pulak et al. argue that these locations would be under significant stress due to the action of the sea.⁷⁰⁵

It can therefore be assumed that during the repair of the ship, the shipwright used timber from different tree species to reinforce the hull, at least with the frames. Since these are warships are most probably the products of an imperial shipyard or shipwrights employed by the navy, whether in Constantinople or a maritime theme, there are several possibilities. The shipyards might have had enough stocks of timber for the construction of a certain number of ships at one time, thus when the ship had to be repaired, the same tree was already used up. Or, the ship was not repaired at the shipyard where it was constructed at all, and these reinforcements were installed at a safe shipyard, harbor, or a landing site along the coasts. Another reason might be an overall lack of concern with the material, since the ship was old, the shipwrights might have disregarded the need to provide the original construction material, such as Oriental plane (*Platanus orientalis*), but might have opted for any readily available material to quickly fix the ship.

When the four galleys excavated by Istanbul University are also considered, a wider diversity of timber types used in galley construction are apparent. For the keels of YK 13, both Oriental plane (*Platanus orientalis*) and oak (*Quercus*) were used, and YK 36 had a keel of Oriental plane (*Platanus orientalis*).⁷⁰⁶ No keel timbers were recovered from the other shipwrecks studied by the Istanbul University. European black pine (*Pinus nigra*) is a consistent element in the hull planking in all of these galleys. However, in the galleys YK 25 and YK 36, both dating to 10th -11th centuries, other species were also used;⁷⁰⁷ In YK 25's hull, for example, half of the samples taken from the hull planking proved to be Taurus cedar (*Cedrus libani*) and in YK 36 chestnut (*Castanea sativa*) was used heavily in addition to oak (*Quercus*), stone pine (*Pinus pinea*), and Oriental plane (*Platanus orientalis*). The variety in timber types is more visible in the framing of the galleys (See Table 4-3). Oriental plane (*Platanus orientalis*) made up the biggest portion

⁷⁰⁵ Pulak, et al.2015, 68; Pulak 2018, 266.

⁷⁰⁶ Akkemik 2015, 49-54, 137-39; Akkemik and Kocabaş 2013, 34.

⁷⁰⁷ Akkemik 2015, 93-6, 137-39.

of the frames in all of the galleys, while Elm (*Ulmus*) was an important component of the frames of YK 13 and YK 16.⁷⁰⁸ Thus, it is not safe to say that the galleys were made with only a limited species of trees in order to maintain the standards required for a warship; however certain species might have been considered interchangeable for the hull planking. Still, it can be seen that the majority of the tree types were Oriental plane (*Platanus orientalis*) for the frames and some longitudinal timbers and European black pine (*Pinus nigra*) for the hull planking.

The warships therefore had specific construction requirements in order to perform well in the sea, and the timber choices were made accordingly. It is interesting however to see that repairs, compared to the original ship itself was much more diverse. However, it must be remembered that the warships after a long time of use could be utilized for different purposes. Thucydides, for example, mentions that during Pericles' expeditions in 430 horse transport ships were made out of "old *triereis*" (Thuc. II.Ivi.2); they could also be dismantled and salvaged for spare parts for other ships. It must also be kept in mind that the warships were commissioned by the emperor or the governors of the maritime themes, and even when the empire was in dire economic straits, as shown before, great efforts were likely made to acquire the necessary materials for the navy. Therefore, the repairs could have been made with the available material at that moment. Overall, the timbers that were used for the construction of the galleys were of high quality.

Roundships

Roundships however, present a different picture. From the Theodosian Harbor, approximately 31 roundships were identified. The level of preservation for each vessel is different, and it is not useful here to analyze each ship. However, certain trends can be observed in a chronological perspective.

⁷⁰⁸ Akkemik 2015, 49-54, 57-64.

Table 4-4 Roundships Excavated from the Theodosian Harbor

Ship	Dating	Part of the Ship		
		Keel	Frames	Planking
YK 34 ⁷⁰⁹	400-500	Red oak (<i>Quercus</i>) Beech	Red oak (<i>Quercus</i>)	European black pine (<i>Pinus nigra</i>)
YK 35 ⁷¹⁰	400-500	Elm (<i>Ulmus</i>) Turkish pine (<i>Pinus brutia</i>) Mediterranean cypress (<i>Cupressus sempervirens</i>)	Elm (<i>Ulmus</i>) Turkish pine (<i>Pinus brutia</i>)	Mediterranean cypress (<i>Cupressus sempervirens</i>)
YK 26 ⁷¹¹	400-600	-	Red oak (<i>Quercus</i>)	Red oak (<i>Quercus</i>)
YK 22 ⁷¹²	430-606	White oak (<i>Quercus</i>) Mediterranean cypress (<i>Cupressus sempervirens</i>)	White oak (<i>Quercus</i>) Red oak (<i>Quercus</i>)	Mediterranean cypress (<i>Cupressus sempervirens</i>)
YK 11 ⁷¹³	607-662	Turkey oak (<i>Quercus cerris</i>)	Turkish pine (<i>Pinus brutia</i>)	Turkish pine (<i>Pinus brutia</i>)
YK 17 ⁷¹⁴	652-870	Stone pine (<i>Pinus pinea</i>)	Stone pine (<i>Pinus pinea</i>)	Stone pine (<i>Pinus pinea</i>)
YK 14 ⁷¹⁵	664-942	Turkey oak (<i>Quercus cerris</i>)	Turkey oak (<i>Quercus cerris</i>)	Turkey oak (<i>Quercus cerris</i>)

⁷⁰⁹ Tentatively dated to the 5th century based on its stratigraphic context. See Kocabaş 2015, 21-2. Akkemik 2015, 119-24.

⁷¹⁰ Dated by the ceramic cargo. See Kocabaş 2015, 23-6. Akkemik 2015, 125-36.

⁷¹¹ Dated based on stratigraphic context. See Kocabaş 2015, 17. Akkemik 2015, 97-8.

⁷¹² Radiocarbon dating to cal CE 435–606. See Kocabaş 2015, 17. Sample OxA-23849 dated to cal CE 435–606 with 95.4% and cal CE 529–606 with 75.4% probability. Sample OxA-23850 dated to cal CE 430–566 with 95.4% probability. Akkemik 2015, 85-92.

⁷¹³ 11 different samples were dated with radiocarbon analysis. See Ingram 2018, 105 for the results of the analysis. A lead seal found within the ship dates to CE 610 – 695, indicating that ship was abandoned after 610 CE. The pottery from the same stratigraphic layer also dated to 6th-7th centuries. For the timber types, see Ingram 2018, 108.

⁷¹⁴ Radiocarbon dating to cal CE 652–870. See Kocabaş 2015, 17. Sample OxA-23843 dated to cal CE 685–870 with 95.4% probability. Sample OxA-23844 dated to cal CE 652–769 with 95.4% and cal CE 652–719 with 76.9%. Akkemik 2015, 65-8.

⁷¹⁵ 12 different samples were dated with radiocarbon analysis. See Jones 2017, 225 for the results of the analysis. Although the pottery associated with the ship points to late 9th or 10th century CE, the radiocarbon analysis and the dendrochronological date of a plank fragment found under the hull points to a construction date of early 9th century (Jones 2017, 253-54). For the timber types, see Liphschitz and Pulak 2009, 168; Jones 2017, 258.

		Part of the Ship		
Ship	Dating	Keel	Frames	Planking
YK 3 ⁷¹⁶	668-987	Eastern Plane (<i>Platanus orientalis</i>)	Eastern plane (<i>Platanus orientalis</i>) Elm (<i>Ulmus</i>)	European black pine (<i>Pinus nigra</i>)
YK 12 ⁷¹⁷	672-876	Hornbeam (<i>Carpinus</i>) Beech (<i>Fagus</i>)	Ash (<i>Fraxinus</i>) Oak (<i>Quercus</i>)	Chestnut (<i>Castanea</i>)
YK 27 ⁷¹⁸	672-896	Stone pine (<i>Pinus pinea</i>)	Evergreen oak (<i>Quercus</i>)	Stone pine (<i>Pinus pinea</i>)
YK 20 ⁷¹⁹	687-975	Beech (<i>Fagus</i>)	Oak (<i>Quercus</i>)	Chestnut (<i>Castanea</i>)
YK 10 ⁷²⁰	700-800	-	Stone pine (<i>Pinus pinea</i>)	Mediterranean cypress (<i>Cupressus sempervirens</i>) Stone pine (<i>Pinus pinea</i>)
YK 19 ⁷²¹	700-800	White oak (<i>Quercus</i>) Eastern plane (<i>Platanus orientalis</i>)	White oak (<i>Quercus</i>)	White oak (<i>Quercus</i>)
YK 29 ⁷²²	700-800	Turkish pine (<i>Pinus brutia</i>)	Elm (<i>Ulmus</i>) Turkish pine (<i>Pinus brutia</i>)	Mediterranean cypress (<i>Cupressus sempervirens</i>)

⁷¹⁶ Radiocarbon dating to cal CE 652–870. See Kocabaş 2015, 17. Sample OxA-23833 dated to cal CE 827–987 with 95.4% and cal CE 865–987 with 93.8% probability. Sample OxA-23845 dated to cal CE 668–809 with 95.4% and cal CE 668–782 with 92.4% probability. Akkemik 2015, 23-6.

⁷¹⁷ Radiocarbon dating. See Kocabaş 2015, 17. Sample OxA-23836 dated to cal CE 681–870 with 95.4% probability. Sample OxA-23837 dated to cal CE 690–876 with 95.4% and cal CE 762–876 with 60.1% probability. Sample OxA-23838 dated to cal CE 672–859 with 95.4% and cal CE 672–818 with 93.4% probability. The amphora finds are dated to the 9th century. See Özsait-Kocabaş 2018, 357-60. Akkemik 2008, 203-11. Akkemik 2015, 43-8.

⁷¹⁸ Radiocarbon dating. See Kocabaş 2015, 17. Sample OxA-23841 dated to cal CE 680–869 with 95.4% probability. Sample OxA-23842 dated to cal CE 672–858 with 95.4% and cal CE 672–815 with 93.5% probability. Akkemik 2015, 99-103.

⁷¹⁹ Radiocarbon dating. See Kocabaş 2015, 17. Sample OxA-23839 dated to cal CE 687–871 with 95.4% probability. Sample OxA-23840 dated to cal CE 782–975 with 95.4% and cal CE 855–975 with 83.9% probability. Akkemik 2015, 77-81.

⁷²⁰ Dated based on stratigraphic context. See Kocabaş 2015, 19. Akkemik 2015, 39-43.

⁷²¹ Dated based on stratigraphic context. See Kocabaş 2015, 17. Akkemik 2015, 73-6.

⁷²² Dated based on stratigraphic context. See Kocabaş 2015, 21. Akkemik 2015, 105-8.

		Part of the Ship		
Ship	Dating	Keel	Frames	Planking
YK 15 ⁷²³	700-900	White oak (<i>Quercus</i>)	-	Stone pine (<i>Pinus pinea</i>)
YK 30 ⁷²⁴	700-900	White oak (<i>Quercus</i>)	Red oak (<i>Quercus</i>) Turkish pine (<i>Pinus brutia</i>)	Mediterranean cypress (<i>Cupressus sempervirens</i>) White oak (<i>Quercus</i>)
YK 32 ⁷²⁵	700-900	White oak (<i>Quercus</i>)	Red oak (<i>Quercus</i>) White oak (<i>Quercus</i>)	Chestnut (<i>Castanea</i>) White oak (<i>Quercus</i>)
YK 23 ⁷²⁶	750-850	Turkey oak (<i>Quercus cerris</i>)	Turkey oak (<i>Quercus cerris</i>)	Turkey oak (<i>Quercus cerris</i>)
YK 31 ⁷²⁷	800-900	White oak (<i>Quercus</i>) Poplar (<i>Populus</i>)	Oak (<i>Quercus</i>)	Oak (<i>Quercus</i>) Chestnut (<i>Castanea</i>)
YK 21 ⁷²⁸	800-1000	White oak (<i>Quercus</i>) Eastern plane (<i>Platanus orientalis</i>)	White oak (<i>Quercus</i>)	White oak (<i>Quercus</i>)
YK 1 ⁷²⁹	900-1000	Turkey oak (<i>Quercus cerris</i>)	Turkey oak (<i>Quercus cerris</i>)	Turkey oak (<i>Quercus cerris</i>)
YK 5 ⁷³⁰	900-1000	Turkey oak (<i>Quercus cerris</i>)	Turkey oak (<i>Quercus cerris</i>)	Turkey oak (<i>Quercus cerris</i>)
YK 6 ⁷³¹	900-1000	Hornbeam (<i>Carpinus</i>)	Chestnut (<i>Castanea</i>) White oak (<i>Quercus</i>)	Chestnut (<i>Castanea</i>) White oak (<i>Quercus</i>)

⁷²³ Dated based on stratigraphic context. See Kocabaş 2015, 20. Akkemik 2015, 55-6.

⁷²⁴ Dated based on stratigraphic context. See Kocabaş 2015, 18. Akkemik 2015, 109-11.

⁷²⁵ Dated based on stratigraphic context. See Kocabaş 2015, 21. Akkemik 2015, 115-18.

⁷²⁶ Dated based on coin find of Nicephorus I (r. 802–811). See Pulak et al. 2015, 50-3.

⁷²⁷ Dated based on stratigraphic context. See Kocabaş 2015, 21. Akkemik 2015, 111-14.

⁷²⁸ Dated based on stratigraphic context. See Kocabaş 2015, 20-1. Akkemik 2015, 81-4.

⁷²⁹ Dated based on the cargo of several dozen amphoras of a piriform shape. See Pulak et al. 2015, 59-62. Liphshitz and Pulak 2009, 166-7.

⁷³⁰ Dated based on stratigraphic context and artefact finds. See Pulak et al. 2015, 55-7. Liphshitz and Pulak 2009, 167.

⁷³¹ Dated based on stratigraphic context. See Kocabaş 2015, 11. Akkemik 2015, 27-31.

		Part of the Ship		
Ship	Dating	Keel	Frames	Planking
YK 7 ⁷³²	900-1000	Red oak (<i>Quercus</i>)	White oak (<i>Quercus</i>)	Chestnut White oak (<i>Quercus</i>)
YK 8 ⁷³³	900-1000	Beech (<i>Fagus</i>)	White oak (<i>Quercus</i>)	Chestnut (<i>Castanea</i>)
YK 9 ⁷³⁴	900-1000	White oak (<i>Quercus</i>)	White oak (<i>Quercus</i>)	Chestnut White oak (<i>Quercus</i>)
YK 18 ⁷³⁵	900-1000	White oak (<i>Quercus</i>) Eastern plane (<i>Platanus orientalis</i>)	White oak (<i>Quercus</i>)	White oak (<i>Quercus</i>)
YK 24 ⁷³⁶	900-1000	Turkey oak (<i>Quercus cerris</i>)	Turkey oak (<i>Quercus cerris</i>)	Turkey oak (<i>Quercus cerris</i>)

Different parts of the roundships can be analyzed individually. For the keels for example, there seems to be a preference towards broad leaved trees, such as oaks –both white and red oaks– beech (*Fagus*) and Eastern plane (*Platanus orientalis*). While seventeen out of twenty-eight ships have part or all of their keels made from oak, beech and Eastern plane (*Platanus orientalis*) were found on four ships each. It should be recalled that Theophrastus gives specific tree species for the keels, for merchant ships, the keel must be made from fir, but an oaken false keel is fastened under it when hauling to the beaches (which is replaceable when worn out), and, for smaller vessels, beech was preferred (Theophr. *Hist. pl.* V.vii.1).⁷³⁷ Oak and beech are indeed observed as keels, however fir is absent from the Yenikapı assemblage's keels. In fact, the use of conifers as keels such as Stone pine (*Pinus pinea*) and Mediterranean cypress (*Cupressus sempervirens*) are confined to the finds dating to earlier periods. The fir species that are found close to the Marmara region are Caucasian fir (*Abies nordmanniana*), a fir of the

⁷³² Dated based on stratigraphic context. See Kocabaş 2015, 11-4. Akkemik 2015, 31-2.

⁷³³ Dated based on stratigraphic context. See Kocabaş 2015, 14. Akkemik 2015, 33-6.

⁷³⁴ Dated based on stratigraphic context. See Kocabaş 2015, 15. Akkemik 2015, 37-8.

⁷³⁵ Dated based on stratigraphic context. See Kocabaş 2015, 16. Akkemik 2015, 69-72.

⁷³⁶ Dated based on stratigraphic context. See Pulak et al. 2015, 57-9.

⁷³⁷ Steffy 1985 suggests that the false keel of the Kyrenia shipwreck might have been replaced.

high montane zone of the mountains around the eastern Black Sea, at elevations between 900 m and 2100 m above sea level.⁷³⁸ Although this species grows very fast, Akkemik points out that it is not very durable in moist conditions.⁷³⁹ Therefore, the lack of *Abies* in the Yenikapı assemblage –not only for the keels but in general– might be associated with the fact that it is both a highland species, thus logistically harder to acquire, and might not have been a durable shipbuilding timber.

Keels do not seem to present any significant changes in material from the 5th to 11th centuries in the Yenikapı assemblage. Oak for example, is present in every period. Akkemik argues that in the ships from 5th – 7th centuries as well as 7th to 9th centuries conifers are used as keel timbers when other parts of the ship is also made from this type of wood, but this observation is not significant enough to be pointing to a conclusive argument.⁷⁴⁰ On the other hand, his observation that conifers cease to be used for keels after 10th century holds true for the Yenikapı assemblage.⁷⁴¹ However, this is not necessarily a transition from conifers to broadleaved trees, but an apparent abandonment of conifers after a certain period, as oaks were being used from the 5th century onwards concurrently with conifers.

For the planking, both conifers and broad-leaved trees are used. The conifers are mostly Turkish pine (*Pinus brutia*) and Mediterranean cypress (*Cupressus sempervirens*), which are found together in low altitude forests. These species can be observed until the 8th century, and after that broad-leaved trees, mostly oak and chestnut are present. It must be reminded that chestnut is a cultivated tree, produced not only for its timber but also for its nuts. Its timber, on the other hand, is very durable and rot-resistant, and is easy to work.⁷⁴² Because it can grow up to 30 m and is found at the sea level around the Marmara, Northern Aegean as well as the Black Sea region, it would have been a favorable choice for the shipwrights. The oaks that are used in the planking are mostly White oak species, which are “robust, season well, and shrink little”, which makes them very ideal for use in

⁷³⁸ Farjon 2017, 109.

⁷³⁹ Akkemik 2015, 147. Farjon 2017 111.

⁷⁴⁰ Akkemik 2015, 186.

⁷⁴¹ Akkemik 2015, 186.

⁷⁴² Akkemik 2015, 160.

shipbuilding.⁷⁴³ Theophrastus states that generally fir is used, meanwhile in Syria cedar and in Cyprus Aleppo pine is preferred (Theophr. *Hist. pl.* V.vii.1). Pliny mentions fir and cedar as well and adds larch (Plin. *HN.* XVI. Xviii.41-2). None of these species are dominant in the planking of the Yenikapı assemblage.

For the frames, just like the keels, oak is being used from early 5th century CE, until the latest find. The conifers that was used on the other hand are Stone pine (*Pinus pinea*) and Turkish pine (*Pinus brutia*). Although Mediterranean cypress (*Cupressus sempervirens*) has been used for hull planking, most probably because it is a straight tree, it is not a dominant choice for any of the ship's frames. It can be seen that no conifers are present in the frames of the ships that if it is too straight to yield compass timbers. In addition to that, both Stone pine (*Pinus pinea*) and Turkish pine (*Pinus brutia*) are lowland trees and can be accessed easily, which would have made them more desirable for the shipwright.

One of the tree species that should be discussed in further detail is oak. The identification of oak in shipbuilding (or in any other sample) has been an ongoing debate between dendroarchaeology specialists. Akkemik for example argues that oak can only be identified down to three groups: white, red and evergreen oaks.⁷⁴⁴ Wazny also suggests that the different species within the subgenus *Quercus* cannot be distinguished on the basis of their wood anatomy.⁷⁴⁵ Liphshitz, on the other hand, identifies oak down to the species level, with the identification of Turkey oak (*Quercus cerris*) in YK 4, YK 23, YK 1, YK 5, YK 11, YK 14, Dor 2001/1, Yassiada II and Bozburun, as well as Turkey oak (*Quercus cerris*), Kermes oak (*Quercus coccifera*), Sessile oak (*Quercus petraea*) in Dor 2006.⁷⁴⁶ There still is not a universal consensus on if the identification of oak down to species is possible or not, as various specialists argue for different identification levels for oak, with the majority arguing that it is not possible to identify down to the species level.

Oak has been found prevalently in the Yenikapı assemblage, and it has been used extensively in Byzantine shipbuilding. Oak was used as the primary construction material

⁷⁴³ Liphshitz and Pulak 2009, 169-70.

⁷⁴⁴ Akkemik 2015, 175.

⁷⁴⁵ Wazny 2009, 42.

⁷⁴⁶ Liphshitz 2012a; Liphshitz and Pulak 2007/2008; Liphshitz and Pulak 2009; Navri et al. 2013, 316.

in most of the shipwrecks recovered from the Theodosian Harbor, dating from the 5th century to the 11th. It is a strong, durable, and pest-resistant hardwood and therefore could be considered ideal for certain uses in shipbuilding. In the Theodosian Harbor shipwreck assemblage, evergreen, white and red oak were identified. The white oak group can grow up to 40 meters tall, and as mentioned previously they are robust, season well and shrink little, which makes it more suitable for shipbuilding. In this region, the common endemic species are downy oak (*Quercus pubescens*) or common oak (*Quercus robur*). Red oaks, although being as strong as white oaks, have open grains and are very porous, and liable to shrinking and rot, and they also grow to shorter lengths, which makes them less desirable.⁷⁴⁷ Still, both of these were used for shipbuilding, while an unidentified red oak was used as the hull planking timber where the ship has direct contact with the water on only one shipwreck (YK 6). Turkey oak (*Quercus cerris*), on the other hand that grows in a wide swath across Turkey and central Europe was used in many Yenikapı ships extensively especially after the 7th century (such as YK 11, YK 14, YK 23, YK 1, YK 5, YK 24) is usually considered a member of the red oak group.⁷⁴⁸ Ships such as YK 7, YK 30 and YK 32 were constructed with red oak. In YK 34 for example, dating to 5th – 6th centuries CE, majority of the framing was made of red oak, which is considered to be of lower quality, while the hull planking was of European black pine (*Pinus nigra*), which has been generally regarded as high quality shipbuilding timber.

This has led to discussions about this specific change, arguing that the earlier uses of the conifers were from planted trees and later the shipwrights have started using “local” wood in the Marmara region.⁷⁴⁹ It has been observed in the Yenikapı evidence that from 5th to 9th centuries as pine and cypress timber decreased in use, disappearing completely in 10th and 11th centuries, while the use of oak and chestnut became more prevalent.⁷⁵⁰ It has already been discussed that economics played an important role in the construction of merchant ships.⁷⁵¹ Pulak has proposed that “the reliance on oak for ship construction might have been dictated by the availability and cost of timber.”⁷⁵² For example, since red oak –although not exactly ideal for shipbuilding due to rotting– was possibly more

⁷⁴⁷ Liphschitz and Pulak 2009, 170.

⁷⁴⁸ Davis 1982, 674; Jones 2017, 257.

⁷⁴⁹ See, for example, Akkemik and Kocabaş 2014, 325.

⁷⁵⁰ Pulak 2018, 277.

⁷⁵¹ Steffy 1994, 10.

⁷⁵² Pulak 2018, 277.

readily available to the shipwrights in close proximity of Constantinople and this would reduce the timber transportation costs.⁷⁵³ However, the drawbacks of using a cheaper alternative would have been the tendency of the ships to rot faster than other species. All of the Yenikapı ships have been covered with a layer of pine pitch, both on the exterior and the interior of the hulls to reduce rotting, which could have been caused by using trees such as the red oak groups.⁷⁵⁴

Jones also proposes that this might have been linked to changes in the cost of shipbuilding timber, obtained either locally (as Akkemik and Kocabaş suggests) or through a reliable source along maritime trade routes.⁷⁵⁵ Trade routes must be emphasized here, as the timber could have easily been exported, whether oaks or conifers. As mentioned earlier, there is evidence for much of the equipment and some of the crew of Serçe Limanı having an origin in the Marmara Sea region, because the clay analysis of the cooking and storage jars belonging to the ship points to an origin from this region.⁷⁵⁶ Van Doorninck does point to Antioch as the construction center for there is a “solid” Turkish pine (*Pinus brutia*) distribution in that region; however this tree is distributed to a wider geographical range, such as around Asia Minor including Northern Aegean, the Gallipoli region and the island of Imbros.⁷⁵⁷ Considering that the Serçe Limanı shipwreck was made of Turkish pine (*Pinus brutia*), dating later than all of the Yenikapı shipwrecks, it is not possible to say that the ships in this region were being made of broad-leaved trees after the 9th century. However, it must also be considered that oaks readily sprout after felling whereas pine fails to regenerate, and thus oak might have been easier to sustain compared to pine.⁷⁵⁸ Thus, it is not possible to determine why the shipwrights have abandoned the use of conifers after a certain period of time, but economic considerations, local availability and environment can be proposed as possible reasons.

In general, there are not specific preferences for merchant ships. The structural considerations and economic resources that went into the decision-making regarding warship building does not seem to be prominent in merchant ships. Both the conifers and

⁷⁵³ Pulak 2018, 277.

⁷⁵⁴ Pulak 2018, 277.

⁷⁵⁵ Jones 2017, 257.

⁷⁵⁶ Van Doorninck 2002b, 139.

⁷⁵⁷ Van Doorninck 2012, 132. Davis 1965:1, 74-5.

⁷⁵⁸ Eastwood et al. 1998, 74.

the broad-leaved trees used extensively in merchant ship construction, such as Turkish pine (*Pinus brutia*), Aleppo pine (*Pinus halepensis*), Stone pine (*Pinus pinea*), Chestnut (*Castanea sativa*) as well as the various oak species including Turkey oak (*Quercus cerris*), are lowland species that grow around the sea level, making them easy to acquire. These species are also suitable to the Mediterranean climate and proliferate easily, and provide both straight timbers for hull planking and compass timbers for keels and frames.

4.4 Pitch

Pitch, has been a standard waterproofing method in the Mediterranean, and a variety of shipwrecks have been covered in pitch to ensure water tightness.⁷⁵⁹ Pitch production in fact was a very developed forest industry.⁷⁶⁰ The ships would have been first caulked, which is to drive oakum, moss, animal hair, grass, or other fibrous material mixed with heated pitch into the seams of planking and then covered with another layer of pitch to make the seams watertight.⁷⁶¹ In fact, one of the emperors, –although he reigned about only five months between December 1041 and April 1042– was called Michael V Kalaphates (Καλαφάτης), which means “caulker” due to his father’s early occupation, who later became an admiral. This can be seen in Michael Psellos’ *Chronographia* written in 11th century where he relates Michael V’s father, Stephen:

What he did was this: when others had done the assembling, he very skillfully smeared the assembled parts with pitch. There was not a boat, freshly built, which could ever be launched on the sea, unless this fellow, with his cunning skill, had first given it the finishing touch. (Psellos, *Chronographia*, IV.26)

Therefore, the use of pitch is not only widely documented with archaeological evidence, both from production centers but also the shipwrecks themselves, and is found in the written sources. The ships from the Theodosian Harbor were covered externally and internally with pitch. It was however noted that more pitch would be applied to the

⁷⁵⁹ The use of pitch was not region or time specific. Many shipwrecks recovered in the Mediterranean have been found with coatings of pitch. Saint-Gervais 3 (2nd century CE), La Bourse (Lacydon) (3rd century CE), Dramont F (4th century CE), Bataiguièr (10th century CE) can be mentioned just to name a few. See Pomey et al. 2012.

⁷⁶⁰ Orengo et al. 2013.

⁷⁶¹ Steffy 1994, 268.

areas that rot, in YK 14 for example, on the surviving wale, thick deposits of up to 23mm were measured in one area of severe rot damage.⁷⁶²

4.5 Joinery

Timber types that were used in the construction of the ships might have been affected by the construction techniques, and especially the joinery. In shell-first construction, relatively thicker planks were used, and mortises were cut into them, and the tenons would be placed in these spaces. In the Uluburun shipwreck's hull, for example, planks were as thick as 6 cm, while in Kyrenia it was around 3-4 cm.⁷⁶³ This was as low as 2.3 cm in YK 14.⁷⁶⁴ If the planks are made of softwood such as pine, it is easier to carve for the mortise, and the tenons were often was of hardwood such as oak.⁷⁶⁵ The Kyrenia shipwreck from 4th century BCE for example where many mortise-and-tenon joints were used, was made mostly of Turkey pine (*Pinus brutia*) and the tenons were made of Kermes oak (*Quercus coccifera*) and Turkey oak (*Quercus cerris*).⁷⁶⁶ The same is the case for the Ma'aghan Mikhael A shipwreck, dating to 5th century BC, whose mortise-and-tenon joints were made of hardwood (Kermes oak, *Quercus coccifera*) inserted into softwood mortises (Turkish pine, *Pinus brutia*).⁷⁶⁷

It must also be emphasized that the ships which were built from oak in Yenikapı were often edge-joined with coaks or dowels rather than mortise-tenon joints.⁷⁶⁸ Outside this assemblage, the Bozburun shipwreck was also built with oak which utilized wooden dowels (or coaks) rather than mortise-and-tenon joints.⁷⁶⁹ There might have been a connection between using oak and the general preference of coaks to mortise-and-tenon joints. Pulak and Jones suggest that the use of coaks instead of mortise-and-tenon joinery might have been a labor-saving choice, as drilling holes for the coaks is easier and faster than cutting mortises for mortise and tenon joints.⁷⁷⁰ This might have also been a choice due to the change in material, as oak is harder than pine, it may have been much harder

⁷⁶² Jones 2017, 264.

⁷⁶³ Steffy 1985, 79; Pulak 1998, 211.

⁷⁶⁴ Jones 2017, 261.

⁷⁶⁵ Steffy 1994, 43-6.

⁷⁶⁶ Liphschitz 2009, 21.

⁷⁶⁷ Liphschitz 2009, 21.

⁷⁶⁸ Ingram 2018, 132.

⁷⁶⁹ Harpster 2005a, 2005b.

⁷⁷⁰ Jones 2017, 278; Pulak 2018, 253.

to cut mortises compared to pine.⁷⁷¹ However, this might be considered a Mediterranean phenomenon as mortise-and-tenon joints were sometimes used in oak planking in Roman ships in northern Europe. The County Hall ship for example, recovered from London, dating to late 3rd- early 4th century CE, was constructed with mortise-and-tenon joints but its planking was oak.⁷⁷²

Differently from coaks, treenails are round or polygonal hardwood fasteners, driven through planks and timbers to connect them.⁷⁷³ In YK 14 for example, treenails were used to fasten frames to the hull planking whereas the coaks were used to align and join the lower hull planking edge-to-edge.⁷⁷⁴ From this shipwreck, 650 of the 656 sampled treenails that were identified to the species level were of Turkey oak (*Quercus cerris*); meanwhile the 38 coaks that were analyzed proved to be of six different species.⁷⁷⁵ It seems like treenails were almost exclusively made from oak while for the coaks a certain species was not preferred. From this evidence, Jones suggests that coaks may have been made from trees and shrubs in the immediate vicinity of the construction site, away from where the original construction trees were felled, meanwhile the treenails were manufactured from branches trimmed from larger oak timbers used for the keel, planking, and frames as 580 of the treenail samples originated from branches.⁷⁷⁶ In this way, if the bigger pieces that was to be used for the construction of the ship were being seasoned, the treenails could have also been seasoned with them. In YK 1 and YK 5 for example, the treenails are again from Turkey oak (*Quercus cerris*), which is the main component of the ship's timbers.⁷⁷⁷ Meanwhile in YK 1 all the coaks that were sampled also proved to be of Turkey oak (*Quercus cerris*) but there is more diversity in the coaks of YK 5, which are made of both Turkey oak (*Quercus cerris*) and (*Acer pseudoplatanus*), although compared to YK 14 far fewer samples were analyzed.⁷⁷⁸ Thus, this assumption might be exclusive for YK 14, but should be considered for the other shipwrecks as well, as it shows that the treenails may have been more homogeneous than coaks. However, it

⁷⁷¹ Pulak 2018, 254.

⁷⁷² Marsden 1994, 112.

⁷⁷³ Steffy 1994, 281.

⁷⁷⁴ Jones 2017, 255.

⁷⁷⁵ Jones 2017, 257.

⁷⁷⁶ Jones 2017, 257.

⁷⁷⁷ Liphschitz and Pulak 2009, 170.

⁷⁷⁸ Liphschitz and Pulak 2009, 170.

must be considered that not all edge fasteners were sampled so these represent a small sample size.

4.6 *The Theodosian Harbor Samples and Timber Movement*

The evidence from the Theodosian Harbor had also contributed to the dendrochronological research in the Aegean.⁷⁷⁹ With the cross-matching of 89 oak samples from the docks at Yenikapı and historically documented buildings of Constantinople, a 213 year tree-ring record was created.⁷⁸⁰ Kuniholm et al. had incorporated these results into a 2367- year, 97-site oak chronology for the Northern Mediterranean between 357 BCE to 2004 CE.⁷⁸¹ From this analysis, several provincial similarities have been found.

Thirteen samples of oak from the piers at Yenikapı present a chronology running from 475 to 610 CE, was probably imported from the Black Sea region, from the same region of the timber source used at Capidava in Romania.⁷⁸² Capidava was an important military and civil Roman center, which retained this position during the Byzantine period as well.⁷⁸³ Samples were taken from a Byzantine building next to the main gate of the fort, which was most probably in use until late 6th century. The chronology of these samples run from 463 to 563 and match the abovementioned samples from the Yenikapı excavations.⁷⁸⁴ This, however, is further complicated by the fact that both Constantinople and the Capidava fortress was connected to main trade routes, Constantinople itself lay between the Black Sea and the Mediterranean, where long distance trade has been demonstrated, and Capidava was on the bank of the Danube, the second longest European river which eventually desembogue to the Black Sea.⁷⁸⁵ This has been interpreted in two different ways, either as representing a link between a common source material for both Capidava and Constantinople, or an import of resources from the Danube region itself.⁷⁸⁶

⁷⁷⁹ Pearson 2012, 3402.

⁷⁸⁰ Pearson 2012, 3402.

⁷⁸¹ Kuniholm et al. 2014, 47-89.

⁷⁸² Kuniholm et al. 2015, 67.

⁷⁸³ Ważny et al. 2017, 175.

⁷⁸⁴ Ważny et al. 2017, 180.

⁷⁸⁵ Ważny et al. 2017, 180.

⁷⁸⁶ Kuniholm et al. 2015, 67; Ważny et al. 2017, 181.

It has been demonstrated that timber was one of the most important trade items of the Black Sea coast in antiquity.⁷⁸⁷ Additional data might also support this conclusion. Timber samples from the primary phase of Hagia Sophia, running from 418 CE to 536, fitting to the Justinianic construction phase, have matched the abovementioned data set.⁷⁸⁸ The authors emphasize that this signature is very distinct, “Nowhere else – on the Anatolian, mainland, in Greece, in Greece or in Italy – do we see this, and it seems to be a Black Sea (or environs) peculiarity.”⁷⁸⁹ This also explains the existence of this signature at the Sinop sea wall sequence of the section between towers 24 and 25 running between 374–434 CE.⁷⁹⁰

It was argued by Crow that the region of Dobrudja, where the fortress of Capidava is located, is known for lacking trees, which eliminates the possibility of this region of being the supplier.⁷⁹¹ On the other hand, this region is connected to the Black Sea and via the *quaestura exercitus*, an administrative linkage between the Aegean islands and coastal regions and the Danube zone.⁷⁹² This system, established by Justinian had the purpose of supplying the Danube frontier forces by sea from a secure hinterland.⁷⁹³ It has previously been shown that the Roman military supply system of northern Europe moved timber through these channels and routes to military establishments from long distances. It is very likely that a source in the Black Sea would supply Capidava with the necessary construction material as the transport of the timber would be very easy through the sea and later the Danube.

The existence of the same signature in the Yenikapı and Hagia Sophia’s primary construction phase also points to the supply of the capital through these existing routes. It has previously been pointed out that during the Justinianic period an upsurge of construction activities, not only in the provinces but also in the capital of the Empire, might have necessitated the supply of raw materials. Sinop, on the other hand, has been referred to many times as a region abundant in forest resources. Thus, it is not likely for Sinop to be supplied by external sources. The possible scenario is the supply of both the

⁷⁸⁷ See Hannestad 2007, 85-100 who analyses both the written evidence and the pollen data.

⁷⁸⁸ Kuniholm et al. 2015, 75-7.

⁷⁸⁹ Kuniholm et al. 2015, 77.

⁷⁹⁰ Kuniholm et al. 2015, 79.

⁷⁹¹ Kuniholm et al. 2015, 73 n.64.

⁷⁹² Haldon 1999, 235.

⁷⁹³ Haldon 1999, 68.

Danube region and Constantinople through existing or newly established supply and trade routes. It cannot be determined if there is a directly link between the southern Black Sea shores and the shores of the Danube, or if Constantinople was a central hub for the accumulation of resources which then was redistributed to the provinces. Pearson et al. also confirms that “the source supplying both this region [Capidava] and Constantinople most likely lies on one of the many trade routes around the Black Sea.”⁷⁹⁴ It is clear that a distribution system existed in the Black Sea and the neighboring regions.

⁷⁹⁴ Pearson et al. 2012, 3412.

Chapter 5:

CONCLUSION

Timber supply for Byzantine shipbuilding proves to be a very extensive topic for exploration. From this overview, however, several conclusions can be drawn. Both written evidence of legal documents, historians, geographers, monastic foundational documents, and hagiographies combined with the material evidence of wood remains, from shipwrecks, harbor structures, and architectural constructions as well as proxy data for ancient climate and forest coverage is necessary to have a broader understanding of timber movement during this period. This evidence can be analyzed in three different levels: the environmental level, which dictates the forest coverage and habitats of species, the socio-economic and political level, where different routes of timber movement under state or private investment can be observed from both written and material evidence, and lastly the shipwreck level, as each ship –and even each part of the ship– required certain timber types for their structural necessities. All these levels and types of evidence are of course connected to one other but nevertheless present different aspects of the realities of how timber was supplied for shipbuilding.

The fundamental determinant of timber trade is the environment, as it dictates the nature and geographic distribution of the forest coverage. Each tree type has a certain environment where it can grow, which is a combination of geology, topography, climate, and soils. A change in these factors changes the distribution of certain tree species. For example, climate plays an important role in the altitudes of where a tree can grow. Taurus cedar (*Cedrus libani*) grows at an altitude of 1100–3000 m above sea level with an annual precipitation of 1000 mm to 1500 mm.⁷⁹⁵ If there is a change in the climate, this changes the temperature and moisture at different altitudes of mountains, altering the distribution of the tree. If for example, the climate would change towards hotter winters and less precipitation, then the region would become inhospitable for the cedar, and it might shift towards higher altitudes, making it logistically harder to acquire. This however is different for each species and even subspecies of trees. When it comes to forest coverage in general however, during the Byzantine Period it depended in part on settlement

⁷⁹⁵ Farjon 2017, 266.

patterns. Pollen data shows that there was an expansion of settlements and decrease in forested areas until 7th century. Around the 7th century, however, this pattern was reversed, not due to climatic changes but to anthropogenic activity. The species that invade ex-farmland, pine, cypress, and deciduous oaks are also very common in shipbuilding during this period. In addition to these, the written sources regarding forested areas also provide evidence for the natural environment and how people have interacted with the arboreal resources. A combination of these evidence creates the background for understanding how the supply of timber might have operated during the Byzantine period.

In the socio-economic and political level, the focus of the research is narrowed down to specific aspects of timber supply, provided by both written and material evidence. One of them is the long distance movement of timber. Written sources such as Vitruvius emphasize the importance of certain species for their unique qualities, and shows that areas that lack shipbuilding timber like Egypt or Rhodes had to import timber from long distances to build ships. It is a commodity that is logistically challenging to move; therefore even though the infrastructure and technology for this existed, not everyone could afford to transport intact timber logs of greater lengths. Most of the examples that have been discussed of long distance timber trade have been related to the patronage or activities of the state or the ruling elite. Timber was moved around the Roman Empire to meet the demands of military and state construction projects. Although almost any large construction project such as fortifications, aqueducts or bridges would have used timber, but the vast majority of this the material is not preserved today. When it is, the remains of wood that could be analyzed with dendrochronology and dendroarchaeology from several sites, including the Forum Hadriani in the modern Netherlands or the fortifications at Capidava in Romania, showing that the military supply routes would also be used to move timber around. Timber transport to military establishments was not limited to Europe: the Monastery of St. Catherine at Mount Sinai can also be added as the receiving end of imperial commissioning. Intact timber pieces were transported to Egypt (possibly from Asia Minor) and moved up the mountain with a great investment in logistics by Justinian I (r. 527-565). Although these timbers were used in the catholicon, the monastery was the site of a small garrison as it was a part of the defense line of the Eastern frontier of the Empire.⁷⁹⁶ Protection and expansion were the motivation for the state to

⁷⁹⁶ Forsyth 1968, 5.

invest in long-distance timber movement related to the frontier military establishments, showing that timber supply chains were connected to military supply systems.

The state investment to acquire suitable timber for military projects was also the case for the fleets. Archaeological evidence shows that the galleys recovered from the Theodosian Harbor were made with materials that were of “high quality.”⁷⁹⁷ They were peculiar in their use of Oriental plane (*Platanus orientalis*), which was not the main construction timber for any of the roundships recovered during this period, but was probably acquired to meet the constructional demands of warships. One logistical advantage behind the timber supply for the galleys that were commissioned by the state was the ability of the state to stockpile large amounts of timber to be used for a multitude of ships. The construction of the fleets was thus more organized as timber could be acquired in bulk over long distances. This was also true for the Ottoman Empire after the Byzantines; the movement of timber to Egypt and the Red Sea, for example, was an endeavor of a considerable scale, intricacy, complexity, and expense, and “it was only the imperial state itself that could undertake” such project.⁷⁹⁸ In the 18th century as well, the timber that was felled was being collected from the forests on the Black Sea coast and the Northern Aegean and collected at the capital before being sent to the arsenals. When the relation between the timber from the Sinop sea walls, Capidava and Constantinople is considered, it is logical that the Byzantine Empire would also have storage facilities for wood at the capital. The timber would be transported from the Black Sea coast or the North Aegean to Constantinople, where it would be used for state sponsored construction projects; the expansion of the harbor, church building at the capital or sent to building projects outside the capital. It is logical that the same system could also be supplying the arsenal at the capital for naval shipbuilding. In addition to that, shipbuilding could have been done close to the forests themselves when that region was secure enough for long-term shipbuilding installations. The peasantry also supplied the state with wood and timber as a part of *angareiai*. This would also include the cutting-down and transporting of wood, and in some cases shipbuilding, and certain officials or men of learning were exempt from this labor service (*Cod. Theod.* XI, 15; XI, 18).⁷⁹⁹

⁷⁹⁷ Pulak 2018, 264.

⁷⁹⁸ Mikhail 2017, 157.

⁷⁹⁹ Harvey 1989, 108.

Aside from the concerns to supply and move timber to desired locations, the state had in its interest to restrict its movement outside the Empire. This aspect of resource management on the political level should also be considered: the state ownership and control of woodland, and trade regulations concerning timber in the context of war material exchange. The control over forest resources was a form of political and strategic leverage in diplomatic relations, from the Athenian dependency on Macedonian timber sources or Hadrian's claim to the forests of Lebanon to Alexios IV Angelos' ban on exploiting imperial forests for shipbuilding, it was both an international and a domestic issue. This was predicated on the fact that timber was used for warship and other military construction, so the regulation of the trade of timber was deemed necessary due to its value for navies. The Byzantines could threaten to burn Venetian ships for selling timber to the Muslims or confiscate a Genoese ship which was carrying 1332 oars, 120 beams and large planks and small wooden logs.⁸⁰⁰ Therefore the control of the timber supply extended out from the domestic lands of the Byzantine Empire and became another form of diplomatic leverage in the political dynamics of the Mediterranean.

On the other hand, these regulations do not seem to have been universally enforced, whether because they were ignored, were difficult to implement, or essentially unenforceable. Eger and Durak's point about different types of frontier economies and types of exchanges such as gift giving, ransom payments or prisoner exchanges, and the fact that the Muslims were exploiting the Taurus Mountains show the continuation of exchange between the Byzantine and Muslim communities. This also supports the argument that long distance trade continued after the 7th century and was not completely disrupted by the entrance of the Muslim navy to the Mediterranean Sea. It is not possible to decide how effective the ban on the trade of timber was, because there clearly was an exchange of commodities and possibly between the Byzantines and the Muslims.⁸⁰¹

Individual shipwrecks can also point to this movement of timber. However, the shipwreck evidence is often ambiguous. Methods of dendrochronology and dendroarchaeology are necessary to understand the timber used in the shipwreck, as well as the context of the artifact assemblage from shipwrecks themselves; however, there are

⁸⁰⁰ Jacoby 2001, 109.

⁸⁰¹ McCormick 2001, 591.

drawbacks to these methods are limited by the number and quality of available samples. It can be very hard to determine where a ship was built, based on the constant movement of timber in the Mediterranean which could have supplied the shipyard, several cultural influences on board might point to a mixed crew or more than one port of call. However, the shipwrecks attest to the long distance movement of timber before and after the 7th century as well.

The Tantura E shipwreck, for example, dated to 7th – 9th centuries, have amongst its finds bricks that were sourced to Egypt (possibly to be used as a stove) and *kurkar* stones local to the Levantine coasts.⁸⁰² There is therefore a high probability of the ship operating in this region, but it was made with Turkish pine (*Pinus brutia*), Mediterranean cypress (*Cupressus sempervirens*), Kermes oak (*Quercus coccifera*), Turkish oak (*Quercus cerris*), elm (*Ulmus campestris*), and European ash (*Fraxinus excelsior*) as original construction timbers, all of them native to Asia Minor.⁸⁰³ Therefore, although the ship seems to have operated along the Levantine coast, it seems like the timber used in its construction might have been imported from Asia Minor. The excavators argue that the fact that the frames had different cross sections, and some of them were only partially worked half logs was not optimal.⁸⁰⁴ There were also many “irregularly shaped, exceptionally short, and some were very narrow” planks on the hull of the ship, and a great number of small repair pieces. Therefore they have concluded that this might point to “a shortage of timber or a shipwright without many resources.”⁸⁰⁵ This lack of material could suggest construction in the Levant or Egypt with imported wood from Asia Minor as all the species used in the construction of the ship could be found as native species there.⁸⁰⁶

The shipwreck was dated to 7th – 9th centuries, potentially to the height of contention between the Byzantine and the Muslim navy in the Eastern Mediterranean. Egypt was in fact taken by the Muslims around the mid-7th century. This might show that although naval war was a reality of this period, the movement of timber and ships was not completely restricted. Trade was profitable at all levels, and it brought tax revenue to the

⁸⁰² Israeli and Kahanov 2014, 380.

⁸⁰³ Liphschitz 2012a, 6.

⁸⁰⁴ Israeli and Kahanov 2014, 374.

⁸⁰⁵ Israeli and Kahanov 2014, 375.

⁸⁰⁶ Israeli and Kahanov 2014, 385.

state. It must also be remembered that it was mostly Coptic shipwrights who operated in Egypt even after the Muslim conquest and not only the shipwrights, but the larger community in Alexandria might have preserved their prior connections with suppliers of timber from Asia Minor, Cyprus, Crete or other regions with suitable shipbuilding timber. Therefore, although the volume of trade might have decreased, the existing trade routes where timber have also moved along did not cease with the Muslim naval activity in the Eastern Mediterranean.

At this individual level, each shipwreck points to similar considerations of structural necessities, availability, and economy, but different results in the choices of shipbuilding timber. It must first of all be remembered that the timber that is used in the construction of the ship does not necessarily give accurate information about the location where it was constructed. The material used in the original construction “could have been imported from other regions, represent reused timber from older ships built elsewhere, or repairs made on ships while visiting foreign ports.”⁸⁰⁷ However, shipwrecks can provide evidence for the decision-making of the shipwrights.

The first distinction can be the structural necessities of the ships. The species used for warship construction and merchant ship construction seem to be dependent on different concerns. The use of Oriental plane (*Platanus orientalis*) in warships for example can be explained by its light compass timbers, to both decrease the weight of the ship and also provide the necessary angles for the frames. The use of European black pine (*Pinus nigra*) can also be associated with the necessity to provide long timbers to decrease weak spots on hull planking. On the other hand, merchant ships (especially smaller, short-distance ones) could be made with shorter and heavier timbers, and even be made with recycled timbers from previous ships.

In relation to this, it is clear that the need for compass timbers for the frames and straight planks for the hull planking have determined the timber choices for the shipwrights regardless of the type of ship. Turkish pine (*Pinus brutia*) and Taurus cedar (*Cedrus libani*), for example, grow tall and straight, and thus are not suitable for curved parts of the ships such as the frames, but were very suitable for masts, yards, hull planks,

⁸⁰⁷ Liphschitz and Pulak 2007/08, 73.

wales and keels. Hull planking was often made of uniform species; from one tree trunk, several planks could be extracted. Finding curved pieces, on the other hand, was not necessarily very easy, there is usually a greater variety in the framing and curved elements. For this, compass timbers which are naturally curved pieces would be used, however it would not be easy to acquire the same angle for each paired frame unless cut from the same tree limb. Certain parts of trees or particular tree species could be used to decrease the time spent on the construction, and by using it in the suitable part of the ship where they could fit without requiring excessive time and labor.

In addition to this, the accessibility of the timber seems to have played an important role in the decision-making of the shipwright. For example, Turkish pine (*Pinus brutia*), Aleppo pine (*Pinus halepensis*) and Mediterranean cypress (*Cupressus sempervirens*) are found between approximately 0-1500 m altitude, and these species would be preferred to Taurus cedar (*Cedrus libani*) because cedar has a higher altitude of distribution and thus is more expensive to acquire. Also, these species, such as Turkish pine (*Pinus brutia*) and Mediterranean cypress (*Cupressus sempervirens*) grow in the same forests, and therefore has a higher chance of being used in the construction of the same ship. Most of the trees used in merchant ship construction in fact (such as Turkish pine (*Pinus brutia*), Aleppo pine (*Pinus halepensis*), Stone pine (*Pinus pinea*), Chestnut (*Castanea sativa*) and Turkey oak (*Quercus cerris*)) grow around the sea level and are easy to acquire compared to mountainous species. It is understood that trees –although depending on the species– that grow in higher latitudes grow more slowly, and thus their timber has a stronger, tighter texture, compared to the species that grow on the plains.⁸⁰⁸ However, this advantage in quality especially during the Byzantine period does not seem to be a primary consideration for the shipwrights when it comes to merchant ships.

Rival argues that the size and the tonnage of the ship is also one of the determining characteristics of the timber choice; if the ship is intended to be smaller to fit into the frequent coastal cabotage trade networks around the Mediterranean coasts and could have a shorter time in service, the economic considerations would prevail over the performance of the timber type.⁸⁰⁹ The Yenikapı evidence can be reviewed in this aspect. The merchant

⁸⁰⁸ Rival 1991, 17.

⁸⁰⁹ Rival 1991, 89-90.

ships with a length of 8–10 meters are likely to be vessels designed for these types of short distance voyages. For example, the hull planking of the shipwrecks that belong to this category from the Theodosian Harbor, YK 6, YK 7, YK 8, YK 9, YK 12, YK 18, YK 19, YK 20 and YK 26 were made with either white oak, red oak or chestnut. Larger merchant ships, on the other hand, such as YK 17, YK 22, YK 27, and YK 35, were made with Stone pine (*Pinus pinea*) and Mediterranean cypress (*Cupressus sempervirens*). Although this is a small dataset to come to firm conclusions, it does seem like the shipwrights might have preferred conifers or broad-leaved-trees for different ship sizes, at least in the Marmara Sea region. Although being a source from the Late Antiquity, the comparative prices in the *Edict* might give insight to this preference. Oak was comparatively the cheapest timber in the *Edict*, and while white oak species such as Sessile oak (*Quercus patraea*) are very suitable for shipbuilding, and red oaks are less so, but the *Edict* does not specify the species. Both pine and cypress are more expensive than oak in the *Edict*. Thus, price could possibly be a factor in building smaller, short distance vessels with cheaper wood. On the other hand, since Stone pine (*Pinus pinea*) and Mediterranean cypress (*Cupressus sempervirens*) are softwoods, they would be less dense, lighter and more flexible than hardwoods, which might have made them more preferable for long distance journeys; and would also provide longer pieces of planks fit to larger ships. A similar case was also noted for the Pisa Shipwrecks.⁸¹⁰

When it comes to the construction techniques, this thesis has demonstrated that both during the construction of an individual ship and in general shipbuilding methods, there was a trend towards economization. The shell-based construction method did indeed produce strong and seaworthy hulls; however, it required a longer time, more material and labor. With the frame-based method on the other hand ships could be built faster with less manpower and did not require as much material as the first method. It must nevertheless be considered that shipbuilding is typically a conservative practice. It was transferred as a tradition, and although shipwrights would try new methods, and make minor changes to the ship design, major changes would probably be avoided as it might have proven to be detrimental to the stability of the ship. Therefore, the transition from shell to frame-based construction took more than a millennium and did not take place

⁸¹⁰ See Section 4.1.1 of this thesis.

uniformly around the Mediterranean, and the ships were often made with a mixture of these two methods, an approach which had its own advantages. The owners of smaller ships that were operating in regional trade (such as Tantura A) might have been under more pressure to economize both the capital and operating costs, thus the shipwrights might have experimented more with different construction techniques in smaller vessels. Nevertheless, the general, Mediterranean wide, long-term trend towards more economical construction is clear.

Rival notes that many factors affect the selection of timber for a ship, such as availability, logistics of acquisition, or performance of different tree types, but emphasizes economic considerations to be the most important.⁸¹¹ So, the choice of timber for the individual ship can be seen as a compromise between the structural needs of the ship—due to its type, intent of use and construction technique—and the resources available to the shipwright. Clearly, the timber that was the easiest to acquire, which would be suitable for the part for which it was intended on the ship, would be the priority of the shipwright, especially in private shipbuilding.

It was shown that supply of timber even for just one ship was the result of complex systems affecting the decision-making of the shipwright at the same time. For the methodology of studying timber supply for shipbuilding in Byzantium, Dunn's suggestion of a long-term perspective and interdisciplinary approach was adopted.⁸¹² As this thesis has aimed to accomplish, to reveal these dynamics, various types of evidence, from textual to material, is needed to be evaluated and integrated. It was shown that even casual written references, once contextualized within the exploitation of natural resources could reveal a long term pattern of economic activities.⁸¹³

There is, however, an imbalance between the present evidence of state sponsored and private shipbuilding activities. Most of the written evidence concentrates on state commissioned construction projects. The war galleys recovered from the Theodosian Harbor therefore gives the opportunity to discuss this aspect of shipbuilding in more detail. As the shipwreck evidence is comparatively limited, this evidence could also be

⁸¹¹ Rival 1991, 89-90.

⁸¹² Dunn 1992, 250.

⁸¹³ Dunn 1992, 254.

integrated into timber use in architectural constructions to further investigate the state mechanisms of timber movement. The shipwreck evidence for private or merchant shipbuilding, on the other hand, is larger, while there is far less written evidence regarding these shipbuilding activities. Integrating the shipwreck data into this discussion, however, helps us understand “the 'artefactual' level of Byzantine economic history.”⁸¹⁴

A further study on this topic could be the discussion of different regions in a comparative perspective with more in-depth analysis. Landscape archaeology can provide further information about the timber exploitation trends in a particular region, and possible routes of movement of timber. Another direction of study would be to integrate the written evidence after the 11th century, especially focusing on the Latin sources to understand the trade networks of timber around the Mediterranean. Aside from this, this thesis shows that the material of nautical archaeology and maritime historical sources has the potential to contribute to Byzantine Studies in a much wider perspective than has been so far been realized.

⁸¹⁴ Dunn 1992, 236.

BIBLIOGRAPHY

5.1 Primary Sources

- ‘Abd al-Masīh, Y. and O. H. E. Burmester., trans. 1943. History of the patriarchs of the Egyptian Church, known as the History of the Holy Church, by Sawīrus ibn al-Mukaffa‘, Bishop of al-Ašmūnīn. Le Caire.
- Ashburner, W., ed., and trans. 1976. *The Rhodian Sea-Law*. Darmstadt, Germany: Wilhelm Weichert KG. Original edition, Oxford: Clarendon Press, 1909.
- Carroll, R. and S. Prickett., eds. 2008. *The Bible: Authorized King James Version*. Oxford: Oxford University Press.
- Crisafulli, V.S, J. W. Nesbitt, and J. Haldon, eds. 1996. *The Miracles of St. Artemios*. Leiden: Brill.
- Dalby, A., trans. 2011. *Geoponika, Farm Work: a Modern Translation of the Roman and Byzantine Farming Handbook*. Devon: Prospect Books.
- Dennis, G. T., ed. and trans. 2008. *Three Byzantine Military Treatises*. Washington, DC: Dumbarton Oaks.
- Dennis, G. T., ed. and trans. 2010. *The Taktika of Leo VI. Text, Translation, and Commentary*. Washington: Dumbarton Oaks.
- Dewing, H. B. and G. Downey., trans. 1940. *Procopius. On Buildings. General Index*. Loeb Classical Library 343. Cambridge, MA: Harvard University Press, 1940.
- Forster, E. S. 1929. *Florus. Epitome of Roman History*. Loeb Classical Library 231. Cambridge, MA: Harvard University Press.
- Frendo, D. A. Fotiou and G. Böhlig. trans. 2000. *John Kaminiates The capture of Thessaloniki*. Byzantina Australiensia, 12. Perth: Australian Association for Byzantine Studies.
- Freshfield, E. H., trans. 1938. *Roman Law in the Later Roman Empire. Byzantine Guilds, Professional and Commercial: Ordinances of Leo VI, c. 895, from the Book of the Eparch*. Cambridge: Cambridge University Press.

- Granger, F., trans. 1931. *Vitruvius. On Architecture, Volume I: Books 1-5*. Loeb Classical Library 251. Cambridge: Harvard University Press.
- Hort, A. F., trans. 1916. *Theophrastus. Enquiry into Plants, Volume I: Books 1-5*. Loeb Classical Library 70. Cambridge: Harvard University Press.
- Jaubert, P. A., trans. 1840. *al-Idrisi. La géographie d'Edrisi. Vol. 2*. Paris: Société de Géographie.
- Jones, H. L., trans. 1928. *Strabo. Geography, Volume V: Books 10-12*. Loeb Classical Library 211. Cambridge: Harvard University Press.
- Jones, H. L., trans. 1932. *Strabo. Geography, Volume VIII: Book 17. General Index*. Loeb Classical Library 267. Cambridge: Harvard University Press.
- Jowett, B., trans. 1871. *The dialogues of Plato. Vol. III*. Oxford: Oxford University Press.
- Kramers, J., ed. 1967. *Ibn Hawqal, Kitāb surat al-ard*. Bibliotheca Geographorum Arabicorum 2. Leiden: Brill.
- Kratchkovsky, I., ed. 1988. "Histoire de Yahya Ibn Sa'id d'Antiochie. Arabe et français." *PO* 212:47.4.
- Lopez, R. S. and Raymond, I. W., eds. 2001. *Medieval Trade in the Mediterranean World Illustrative Documents*. New York: Colombia University Press.
- Magoulias, H. J, trans. 1984. *O City of Byzantium, Annals of Niketas Choniates*. Byzantine Texts in Translation. Detroit: Wayne State University Press.
- Mango, C., and R. Scott, trans. 1997. *The Chronicle of Theophanes Confessor. Byzantine and Near Eastern History AD 284-813*. Oxford: Clarendon Press.
- McGing, B. 1912. *Appian. Roman History*. Loeb Classical Library 2. Cambridge: Harvard University Press.
- Miller, F. J., trans. 1916. *Ovid. Metamorphoses, Volume I: Books 1-8*. Loeb Classical Library 42. Cambridge: Harvard University Press.
- Milner, N. P., trans. 1993. *Vegetius. Epitome of Military Science*. N. P. Milner. Liverpool: Liverpool University Press.

- Mommsen, T., P. Krueger, and A. Watson. Trans., 1985. *The Digest of Justinian*. Philadelphia: University of Pennsylvania Press.
- Nystazopoulou-Pelekidou, M., ed. 1980. *Βυζαντινά Έγγραφα Μονής Πατρίου II. Δημοσίων Λειτουργιών*. Athens: Institute for Byzantine Research.
- Perrin, B., trans. 1920. *Plutarch. Lives, Volume IX: Demetrius and Antony. Pyrrhus and Gaius Marius*. Loeb Classical Library 101. Cambridge: Harvard University Press.
- Pharr, C., trans. 1952. *The Theodosian Code and Novels and the Sirmondian Constitutions*. Princeton, NJ: Princeton University Press.
- Rackham, H., trans. 1945. *Pliny. Natural History, Volume IV: Books 12-16*. Loeb Classical Library 370. Cambridge: Harvard University Press.
- Radice, B., trans. 1969. *Pliny the Younger. Letters, Volume I: Books 1-7*. Loeb Classical Library 55. Cambridge: Harvard University Press.
- Rolfe, J. C., trans. 1950. *Ammianus Marcellinus. History, Volume I: Books 14-19*. Loeb Classical Library 300. Cambridge: Harvard University Press.
- Schopen, L., ed. 1829-55. *Nikephoros Gregoras, Byzantina Historia*, CSHB, 3 vols. Bonn: Impensis ed. Weberi.
- Schopen, L., ed. 1832. *Ioannis Cantacuzeni Historiarum libri quattuor. Vol. 3*. Bonn: Impensis ed. Weberi.
- Ševčenko, I., and N. P. Ševčenko, trans. 1984. *The Life of St. Nicholas of Sion*. Brookline: Hellenic College Press.
- Sewter, E. R. A., trans. 1969. *Anna Comnena. The Alexiad*. Harmondsworth: Penguin.
- Sewter, E. R. A., trans. 1979. *Fourteen Byzantine rulers. The Chronographia of Michael Psellos*. Harmondsworth: Penguin.
- Simpson, W. K., ed. 2003. *The Literature of Ancient Egypt: An Anthology of Stories, Instructions, Stelae, Autobiographies, and Poetry*. 3rd ed. New Haven and London: Yale University Press.
- Sternbach, L. ed. 1900. *Theodore Synkellos. Analetica Avarica*. Cracoviae: Sumptibus Academiae Litterarum.

- Thomas, J. P., A. C. Hero, and G. Constable, eds. 2000. *Byzantine Monastic Foundation Documents: A Complete Translation of The Surviving Founders' Typika And Testaments*. Washington: Dumbarton Oaks.
- Thomson, R. W., trans. 1999. *The Armenian History Attributed to Sebeos, 1: Translation and Notes*. Liverpool: Liverpool University Press.
- Torrey, C. C., ed. 1922. *The History of the Conquest of Egypt, North Africa and Spain: known as the Futuh Misr of Ibn Abd al-Hakam edited from the manuscripts in London, Paris and Leyden*. New Haven: Yale University Press.
- Wortley, J., trans. 1992. *John Moschos, The Spiritual Meadow (Pratum Spirituale)*. Kalamazoo: Cistercian Publications.
- Zepos, J. and P. Zepos., eds. 1962. Reprint. *Jus graecoromanum*, 8 vols. Aalen: Scientia. Original edition, Athens, 1931.

5.2 Secondary Sources

- Abdul-Nour, H. 2001. "Les inscriptions forestières d'Hadrien: Mise au point et nouvelles découvertes." *Archaeology and History in Lebanon* 14:64-80.
- Adam, J. P. 2005. *Roman Building: Materials and Techniques*. London and New York: Routledge.
- Agius, D. A. 2008. *Classic Ships of Islam from Mesopotamia to the Indian Ocean*. Leiden, Boston: Brill.
- Ahrweiler, H. 1966. *Byzance et la mer*. Paris: Presses Universitaires de France.
- Akkemik, Ü. 2008. "Identification of Timbers from Yenikapı 12 Shipwreck." In *The 'Old Ships' of the 'New Gate,'* edited by U. Kocabaş, 203-11. Istanbul: Ege Yayınları.
- Akkemik, Ü. 2015. *Woods of Yenikapı Shipwrecks*. Istanbul: Ege Yayınları.
- Akkemik, Ü., and U. Kocabaş. 2013. "Woods of The Old Galleys of Yenikapı, Istanbul." *Mediterranean Archaeology and Archaeometry* 13.2:31-41.
- Akkemik, Ü., and U. Kocabaş. 2014. "Woods of Byzantine trade ships of Yenikapı (Istanbul) and Changes in Wood Use from 6th to 11th Century." *Mediterranean Archaeology and Archaeometry* 14.2:317-27.

- Akkemik, Ü., H. Caner, G. A. Conyers, M. J. Dillon, N. Karlıoğlu, N. K. Rauh and L. O. Theller. 2012. "The archaeology of deforestation in south coastal Turkey." *International Journal of Sustainable Development and World Ecology*, 19.5:395-405.
- Allevato, E., A. Saracino, S. Fici, and G. Di Pasquale. 2016. "The contribution of archaeological plant remains in tracing the cultural history of Mediterranean trees: The example of the Roman harbour of Neapolis." *The Holocene* 26.4:603-13.
- Allevato, E., E. Russo Ermolli and G. di Pasquale. 2009. "Woodland exploitation and Roman shipbuilding. Preliminary data from the shipwreck Napoli C (Naples, Italy)." *Journal of Mediterranean Geography* 112:33-42.
- Arslan M. and M. Aydın. 2011. Ankara Maltepe Kurtarma Kazısı 2009. 19. *Müze Çalışmaları ve Kurtarma Kazıları Sempozyumu*, edited by A. N. Toy and C. Keskin, 305-26.
- Ashburner, W. 1910. "The Farmer's Law." *JHS* 30:85-108.
- Ashburner, W. 1912. "The Farmer's Law (Continued)." *JHS* 32:68-95.
- Baillie, M. G. L. 1997. *A Slice Through Time: Dendrochronology and Precision Dating*. London and New York: Routledge.
- Bakker, J., E. Paulissen, D. Kaniewski, J. Poblome, V. De Laet, G. Verstraeten, and M. Waelken. 2013. "Climate of The Past Climate, People, Fire and Vegetation: New Insights into Vegetation Dynamics In The Eastern Mediterranean Since The 1st Century AD" *Climate of the Past* 9.1:57-87.
- Balard, M. 1978. *La Romanie génoise (XII^e–début du XV^e siècle)*. Rome: École Française de Rome.
- Baran Çelik, G. 2007. "Daily Life in Yenikapı." In *Istanbul: 8,000 Years Brought to Daylight: Marmaray, Metro, Sultanahmet Excavations*, edited by Z. Kızıltan, 220-229. Istanbul, Turkey: Vehbi Koç Vakfı.
- Bardill, J. 2008. "Building Materials and Techniques." In *Oxford Handbook of Byzantine Studies*, edited by E. Jeffreys, with J. Haldon and R. Cormack, 335-53. Oxford: Oxford University Press.

- Barkai, O. 2009. "The Tantura F Shipwreck." In *Between the Seas: Transfer and Exchange in Nautical Technology: Proceedings of the Eleventh International Symposium on Boat and Ship Archaeology, Mainz 2006, ISBSA 11*, edited by R. Bockius, 33-9. Mainz, Germany: Römisches-Germanisches Zentralmuseum.
- Barkai, O., and Y. Kahanov. 2007. "The Tantura F Shipwreck, Israel." *IJNA* 36.1:21-31.
- Barkai, O., and Y. Kahanov. 2016. "The Tantura F shipwreck: Hull Remains and Finds-Final Report." *IJNA* 45.1:6-28.
- Basch, L. 1972. "Ancient Wrecks and the Archaeology of Ships." *IJNA* 1:1-58.
- Bass, G. F. 2011. "The Development of Maritime Archaeology." In *The Oxford Handbook of Maritime Archaeology*, edited by A. Catsambis, D. L. Hamilton, and B. Ford, 3-22. Oxford: Oxford University Press.
- Bass, G. F. and F. H. van Doorninck. 1971. "A fourth-century Shipwreck at Yassı Ada." *AJA* 75: 27-37.
- Bass, G. F. and F. H. Van Doorninck. 2004. "Discovery, Excavation and Coservation." In *Serçe Limanı: An Eleventh Century Shipwreck. Volume I: The Ship and Its Anchorage, Crew, and Passengers* edited by G. F. Bass, S. D. Matthews, J. R. Steffy and F. H. Van Doorninck, 49-70. College Station: Texas A&M University Press.
- Bass, G. F., and F. H. Van Doorninck. 1982. *Yassı Ada: A Seventh-Century Byzantine Shipwreck*. College Station: Texas A & M University Press.
- Bass, G. F., B. Lledo, S. Matthews, and R. H. Brill. 2009. *Serçe Limanı, Vol 2: The Glass of an Eleventh-Century Shipwreck*. College Station: Texas A&M University Press.
- Bass, G. F., P. Throckmorton, J.D.P. Taylor, J.B. Hennessy, A.R. Shulman, and H.G. Buchholz. 1967. "Cape Gelidonya: A Bronze Age Shipwreck." *Transactions of the American Philosophical Society* 57:1-177.
- Bass, G. F., R. H. Brill, B. Lledo and S. D. Matthews, eds. 2009. *Serçe Limanı. Vol 2, The Glass of an Eleventh-Century Shipwreck*. College Station: Texas A&M University Press.

- Bass, G. F., S. D. Matthews, J. R. Steffy and F. H. Van Doorninck. 2004. *Serçe Limanı: An Eleventh Century Shipwreck*. Volume I: *The Ship and Its Anchorage, Crew, and Passengers*. College Station: Texas A&M University Press.
- Bekker-Nielsen, T. 2013. "Transport in Ancient Cyprus." In *Transport Amphorae and Trade of Cyprus*, edited by M. L. Lawall, and J. Lund, 12-9. Aarhus: Aarhus University Press.
- Bellabarba, S. 1996. "The Origins of The Ancient Method of Designing Hulls: A Hypothesis." *Mariner's Mirror* 82: 259-68.
- Bernabei M., J. Bontadi, R. Rea, U. Büntgen, W. Tegel. 2019. "Dendrochronological evidence for long-distance timber trading in the Roman Empire." *PLoS ONE* 14.12:e0224077.
- Bockius, R. 2002. "On the Reconstruction of a Roman River Boat Found at Oberstimm Near Ingolstadt, Bavaria." In *Tropis VII, 7th International Symposium on Ship Construction in Antiquity, Pylos 1999 proceedings*, edited by H. Tzalas, 151-62. Athens: Hellenic Institute for the Preservation of Nautical Tradition.
- Borza, E. N. 1987. "Timber and Politics in the Ancient World: Macedon and the Greeks" *PAPS* 131.1:32-52.
- Bouras, C. 2002. "Master Craftsmen, Craftsmen, and Building Activities in Byzantium." In *The Byzantine Economy*, edited by A. E. Laiou, 539-54. Cambridge: Cambridge University Press.
- Brand, C. M. "Michael Stryphnos." In *The Oxford Dictionary of Byzantium*, edited by A. P. Kazhdan, 1968. New York, Oxford: Oxford University Press.
- Broodbank, C. 2013. *The Making of the Middle Sea: A History of the Mediterranean from the Beginning to the Emergence of the Classical World*. London: Thames & Hudson.
- Browning, R. 1978. "Literacy in the Byzantine World." *BMGS* 4:39-54.
- Browning, R. 1992. *The Byzantine Empire*. Washington DC: The Catholic University of America Press.
- Bryant, V. M. Jr. and R. G. Holloway. 1983. "The Role of Palynology in Archaeology" *Advances in Archaeological Method and Theory*, 6:191-224.

- Buccellato, C. A., and S. Tusa. 2013. The Acqualadroni Ram Recovered Near the Strait of Messina, Sicily: dimensions, timbers, iconography and historical context. *IJNA* 42:76-86.
- Burgmann, L. 1991. "Rhodian Sea Law." In *The Oxford Dictionary of Byzantium*, edited by A. P. Kazhdan, 1792. New York, Oxford: Oxford University Press.
- Canavas, C. 2007. "Timber supply of Muslim states in the medieval Mediterranean. An approach focusing on environmental history and technology transfer" In *Mediterranean Crossroads*, edited by S. Antoniadou, S. and A. Pace, 607-21. Athens: Pierides Foundation.
- Carlson, D. N. 2011. "The Seafarers and Shipwrecks of Ancient Greece and Rome." In *The Oxford Handbook of Maritime Archaeology*, edited by A. Catsambis, D. L. Hamilton, and B. Ford, 379-405. Oxford: Oxford University Press.
- Casson, L. 1963. "Ancient shipbuilding: new light on an old source." *TAPA* 94:28-33.
- Casson, L. 1976. "Dockside cranes." *IJNA* 5.4:345-45.
- Casson, L. 1991. *The Ancient Mariners: Seafarers and Sea Fighters of the Mediterranean in Ancient Times*. Princeton: Princeton University Press.
- Casson, L. 1994. *Ships and Seafaring in Ancient Times*. Texas: University of Texas Press.
- Casson, L. 1995. *Ships and Seamanship in the Ancient World*. Princeton: Princeton University Press.
- Chetkova, B. 1970. *Vie Économique des Villes et Ports Balkaniques aux XVe et XVIe Siècles*. Paris: Paul Geuthner.
- Christensen, A. E., 1973. "Lucien Basch, Ancient Wrecks and the Archaeology of Ships. A Comment." *IJNA* 2:137-45.
- Christides, V. 2006. *The Image of Cyprus in the Arabic Sources*. Nicosia: Cyprus Research Center.
- Coetlogon Williams, P. F. 1976. "Roman Harbors." *IJNA* 5.1:73-9.
- Cohen, M. and D. Cvikel. 2019. "Ma'agan Mikhael B, Israel: a preliminary report of a Late Byzantine–Early Islamic period shipwreck." *IJNA* 48.1:189-207.

- Constable, N. 2005. *Historical Atlas of Ancient Rome*. London: Mercury Books.
- Cosentino, S. 2007. "Constans II and the Byzantine navy." *BZ* 100:577-603.
- Cosentino, S. 2018. "Naval Warfare: Military, Institutional and Economic Aspects." In *A Companion to the Byzantine Culture of War, ca. 300-1204*, edited by Y. Stouraitis, 308-55. Leiden, Boston: Brill.
- Creasman, P. P. 2010. A further investigation of the Cairo Dahshur boats. *Journal of Egyptian Archaeology* 96:101-23.
- Crow, J. 2008. "Archaeology." In *The Oxford Handbook of Byzantine Studies*, edited by E. Jeffreys, with J. Haldon and R. Cormack, 47-58. Oxford: Oxford University Press.
- Crow, J. 2017. "Sinope". In *The archaeology of Byzantine Anatolia: from the end of Late Antiquity until the coming of the Turks* edited by P. Niewohner, 395-400. Oxford: Oxford University Press.
- Crumlin-Pedersen, O. and O. Olsen, eds. 2002. *The Skuldelev ships I: Topography, archaeology, history, conservation and display. Ships and Boats of the North 4-1*. Roskilde: Viking Ship Museum.
- Cutler, A. 2001. "Gifts and Gift Exchange as Aspects of the Byzantine, Arab, and Related Economies." *DOP* 55:247-78.
- D'Auria, A., M. Teobaldelli, and G. Di Pasquale. 2020. "The Late Holocene History of Cypress (*Cupressus sempervirens* L.) in the Italian Peninsula: New perspectives from archaeobotanical data." *The Holocene* 30.2:210-17.
- Dafni, A., S. Levy, and E. Lev. 2005. "The ethnobotany of Christ's Thorn Jujube (*Ziziphus spina-christi*) in Israel." *Journal of Ethnobiology and Ethnomedicine* 1.8:1-11.
- Daly, A. 2007. *The Karschau Ship, Schleswig-Holstein: Dendrochronological Results and Timber Provenance*. *IJNA* 36.1:155-66.
- Darvill, T. 2008. *The Concise Oxford Dictionary of Archaeology*. Oxford: Oxford University Press.
- Davis, P. H., ed. 1965. *Flora of Turkey and the East Aegean Islands*. Vol. 1. Edinburgh, University of Edinburgh Press.

- Davis, P. H., ed. 1967. *Flora of Turkey and the East Aegean Islands*. Vol. 2. Edinburgh, University of Edinburgh Press.
- Davis, P. H., ed. 1970. *Flora of Turkey and the East Aegean Islands*. Vol. 3. Edinburgh, University of Edinburgh Press.
- Davis, P. H., ed. 1972. *Flora of Turkey and the East Aegean Islands*. Vol. 4. Edinburgh, University of Edinburgh Press.
- Davis, P. H., ed. 1978. *Flora of Turkey and the East Aegean Islands*. Vol. 6. Edinburgh, University of Edinburgh Press.
- Davis, P. H., ed. 1982. *Flora of Turkey and the East Aegean Islands*. Vol. 7. Edinburgh, University of Edinburgh Press.
- Davulcu, M. 2015. "Karadeniz Bölgesinde Ahşap Tekne Yapımcılığı ve Günümüzdeki Durumu". *Karadeniz Sosyal Bilimler Dergisi* 7:94-124.
- Dean, J. R., M. D. Jones, M. J. Leng, H. J. Sloane, C. N. Roberts, J. Woodbridge, G. E.A. Swann, S. E. Metcalfe, W. J. Eastwood, H. Yiğitbaşıoğlu. 2013. "Palaeo-seasonality of the last two millennia reconstructed from the oxygen isotope composition of carbonates and diatom silica from Nar Gölü, central Turkey." *Quaternary Science Review* 66:33-44.
- Di Pasquale, G., P. di Martino, S. Mazzoleni. 2004. "Forest History in the Mediterranean Region". In *Recent Dynamics of the Mediterranean Vegetation and Landscape*, edited by S. Mazzoleni, G. di Pasquale, M. Mulligan, P. di Martino and F. Rego, 13-21. West Sussex: John Wiley & Sons.
- Doğu, D., C. Köse, S. N. Kartal, and N. Erdin. 2011. "Wood of An Ancient Port," *BioResources* 6.2:987-1018.
- Dölger, F. 1965. *Regesten der Kaiserurkunden des ostromischen Reiches von 565-1453* vol. 5. Munich: Verlag C. H. Beck.
- Domínguez-Delmás, M., M. Driessen, I. García-González, N. van Helmond, R. Visser, and E. Jansma. 2014. "Long-distance Oak Supply in mid-2nd Century AD Revealed: the case of a Roman harbour (Voorburg-Arentsburg) in the Netherlands." *JAS* 41:642-54.

- Domínguez-Delmás, M., S. Rich, A. Daly, N. Nayling, and K. Haneca. 2019. "Selecting and Sampling Shipwreck Timbers for Dendrochronological Research: practical guidance." *IJNA* 48.1:231-44.
- Dunn, A. 1992. "The Exploitation and Control of Woodland and Scrubland in the Byzantine World." *BMGS* 16:235-98.
- Dunn, A. 1996. "The Control and Exploitation of the Arboreal Resources of the Late Byzantine and Frankish Aegean Region." In *L'uomo e la foresta, secoli XIII-XVIII*, edited by S. Cavaciocchi, 479-97. Firenze: Istituto Internazionale di Storia Economica.
- Durak, K. 2013. "Traffic across the Cilician Frontier: Movement of People between Byzantium and the Islamic Near East in the Early Middle Ages." In *Byzantium and the Arab World, Encounter of Civilizations*. Edited by A. Kralides and A. Gkoutzioukostas, 141-54. Thessalonica: Aristotle University of Thessaloniki.
- Durak, K. 2018. "The Cilician Frontier." In *Center, Province and Periphery in the Age of Constantine VII Porphyrogenetos: From De Ceremoniis to De Administrando Imperio*. Edited by N. Gaul, V. Menze and C. Bálint, 168-83. Wiesbaden: Harrassowitz Verlag.
- Eastwood, W. J., Roberts, N., & Lamb, H. F. 1998. "Palaeoecological and Archaeological Evidence for Human Occupance in Southwest Turkey: the Beyşehir occupation phase." *AnatSt* 48:69-86.
- Efthymiadis, S. and V. Déroche. 2011. "Greek Hagiography in Late Antiquity (Fourth-Seventh Centuries)." In *The Ashgate Research Companion to Byzantine Hagiography, I, Periods and Places*, edited by S. Efthymiadis, 35-94. London and New York: Ashgate.
- Eger, A. 2010. "Hışn al-Tīnāt on the Islamic-Byzantine Frontier: Synthesis and the 2005–2008 Survey and Excavation on the Cilician Plain (Turkey)." *BASOR* 357:49-76.
- Eger, A. 2015. *The Islamic-Byzantine Frontier*. London, New York: I.B. Tauris.
- Eickhoff, E. 1966. *Seekrieg und Seepolitik zwischen Islam und Abendland: Das Mittelmeer unter Byzantinischer und Arabischer Hegemonie (650–1040)*. Berlin: Walter De Gruyter & Co.

- England, A. W. J. Eastwood, C. N. Roberts, R. Turner and J. F. Haldon. 2008. "Historical Landscape Change in Cappadocia (central Turkey): a palaeoecological investigation of annually laminated sediments from Nar lake." *The Holocene* 18.8:1229-245.
- Erim, K. T. and J. Reynolds. 1973. "The Aphrodisias Copy of Diocletian's Edict on Maximum Prices." *JRS* 63:99-110.
- Fagerlie, J. M. 1982. "The Coins". In *Yassı Ada: A Seventh-Century Shipwreck*. Volume I, by G. F. Bass and F. H. van Doorninck, 145-54. College Station: Texas A&M University Press.
- Fahmy, A. M. 1966. *Muslim Naval Organization in the Eastern Mediterranean, From the Seventh to the Tenth Centuries*. Cairo: National Publication & Printing House.
- Farjon, A. 2017. *A Handbook of the World's Conifers: Revised and Up-dated Edition*, 2 vols., Leiden and Boston: Brill.
- Faroghi, S. 1984. *Towns and Townsmen of Ottoman Anatolia: Trade, Crafts, and Food Production in an Urban Setting, 1520–1650*. Cambridge: Cambridge University Press.
- Forsyth, G. H. 1968. "The Monastery of St. Catherine at Mount Sinai: The Church and Fortress of Justinian." *DOP* 22:1-19.
- Forsyth, I. H., and E. Sears. 2016. "George H. Forsyth and the Sacred Fortress at Sinai." *DOP* 70:117-50.
- Foss, C. 1991. "Cities and Villages of Lycia in the Life of Saint Nicholas of Holy Zion." *The Greek Orthodox Theological Review* 36:303-39.
- Gassend J.-M., L. Bernard, X. Serge. 1984. L'épave 2 de l'anse des Laurons (Martigues, Bouches-du-Rhône). *Archaeonautica* 4:75-105.
- Geanakoplos, D. J. 1959. *Emperor Michael Palaeologus and the West, 1258-1282: A Study in Byzantine-Latin Relations*. Cambridge, Massachusetts: Harvard University Press.
- Giachi, G., S. Lazzeri, M. M. Lippi, N. Macchioni, and S. Paci. 2003. "The Wood of "C" and "F" Roman Ships Found in the Ancient Harbour of Pisa (Tuscany, Italy): the utilisation of different timbers and the probable geographical area which supplied them." *Journal of Cultural Heritage* 4: 269-83.

- Gökçay, M. 2010. "Selected Wooden Finds from Yenikapı." In *Istanbul Archaeological Museums Proceedings of the 1st Symposium on Marmaray-Metro Salvage Excavations, 5th-6th May 2008*, edited by U. Kocabaş, 135-52. Istanbul: Istanbul Archaeological Museums.
- Greenhill, B. 1995. *The archaeology of boats and ships : an introduction*, London: Conway Maritime Press.
- Gregory, T. E. 2010. *A History of Byzantium*. Hoboken: John Wiley & Sons.
- Griggs, C., C. Pearson, S. W. Manning, and B. Lorentzen. 2014. A 250-year annual precipitation reconstruction and drought assessment for Cyprus from *Pinus brutia* Ten. tree-rings. *International Journal of Climatology* 34: 2702-714.
- Grove, A. T. and O. Rackham. 2001. *The Nature of Mediterranean Europe: An Ecological History*. New Haven and London: Yale University Press.
- Guibal, F., and P. Pomey. 2004. "Dendrochronologie et construction navale antique." *Revue d'Archeometrie* 28:35-42.
- Günsenin, N. 2009. "Ganos Wine and its Circulation in the 11th Century." In *Byzantine Trade, 4th-12th Centuries: The Archaeology of Local, Regional and International Exchange. Papers of the Thirty-eighth Spring Symposium of Byzantine Studies, St John's College, University of Oxford, March 2004*, edited by M. M. Mango, 145-56. Farnham: Ashgate.
- Günsenin, N. 2017. "Harbours and Shipbuilding in Byzantine Constantinople." In *the Sea in History – Medieval World*, edited by C. Buchet and M. Balard, 412-24. Woodbridge, Suffolk, Rochester: Boydell and Brewer.
- Hakim, B. S. 2001. "Julian of Ascalon's Treatise of Construction and Design Rules from Sixth-Century Palestine." *JSAH* 60.1:4-25.
- Haldon, J. F. 1990. *Byzantium in the Seventh Century: The Transformation of a Culture*. Cambridge: Cambridge University Press.
- Haldon, J. F. 1999. *Warfare, State and Society in the Byzantine World, 565-1204*. London: Routledge.

- Haldon, J. F. 2000. "Theory and practice in tenth-century military administration. Chapters II, 44 and 45 of the *Book of Ceremonies*." *TravMém* 13:201-352.
- Haldon, J. F. 2008. "The Primary Sources". In *The Oxford Handbook of Byzantine Studies*, edited by E. Jeffreys, with J. Haldon and R. Cormack, 21-30. Oxford: Oxford University Press.
- Haldon, J., N. Roberts, A. Izdebski, D. Fleitmann, M. McCormick, M. Cassis, O. Doonan, W. Eastwood, H. Elton, S. Ladstätter, S. Manning, J. Newhard, K. Nicoll, I. Telelis, E. Xoplaki. 2014. "The Climate and Environment of Byzantine Anatolia: Integrating Science, History and Archaeology" *Journal of Interdisciplinary History* 45.2:113-6.
- Hannestad, L. 2007. "Timber as a Trade Resource Of The Black Sea." In *The Black Sea in Antiquity: Regional and Interregional Economic Exchanges*, edited by V. Gabrielsen and J. Lund, 85-100. Aarhus: Aarhus University Press.
- Harpster, M. B. 2002. "A preliminary report on the 9th-century ad hull found near Bozburun, Turkey." In *Tropis VII: Proceedings of the 7th International Symposium on Ship Construction in Antiquity, Pylos, 1999*, edited by H. Tzalas, 409-18. Athens: Hellenic Institute for the Preservation of Nautical Tradition.
- Harpster, M. B. 2005a. "A Re-assembly and Reconstruction of the 9th-Century AD Vessel Wrecked off the Coast of Bozburun, Turkey." Unpublished Ph.D. Dissertation, Texas A&M University.
- Harpster, M. B. 2005b. "Dowels as a Means of Edge-to Edge Joinery in the 9th-Century AD Vessel from Bozburun, Turkey." *IJNA* 34.1:88-94.
- Harris, W. V. 2011a. "Bois et déboisement dans la Méditerranée antique." *Annales HSS* 66, 1:105-40.
- Harris, W. V. 2011b. "Plato and the Deforestation of Attica." *Athenaeum* 99:479-82.
- Harris, W. V. 2013. "Defining and Detecting Mediterranean Deforestation, 800 BCE to 700 CE". In *The Ancient Mediterranean Environment Between Science and History*, edited by W.V. Harris, 173-96. Leiden, Boston: Brill.

- Harris, W. V. 2018. "The Economy of Wood in the Mediterranean." In *Trade, Commerce, and the State in the Roman World* edited by A. Wilson and A. Bowman, 211-36. Oxford: Oxford University Press.
- Harrison, R. M. and N. Fıratlı. 1965. Excavations at Saraçhane in Istanbul: First Preliminary Report. *DOP* 19: 231-36.
- Harrison, R. M. and N. Fıratlı. 1966. Excavations at Saraçhane in Istanbul: Second and Third Preliminary Reports. *DOP* 20: 223-38.
- Harrison, R. M. and N. Fıratlı. 1967. Excavations at Saraçhane in Istanbul: Fourth Preliminary Report. *DOP* 21: 273-78.
- Harrison, R. M., L. B. Hill, M. V. Gill, M. F. Hendy, S. J. Hill, D. Brothwell, and K. Kosswi. 1986. *Excavations at Saraçhane in Istanbul, Vol. 1*. Princeton: Princeton University Press.
- Harrison, R.M., N. Fıratlı, and J. W. Hayes. 1968. "Excavations at Saraçhane in Istanbul: Fifth Preliminary Report, with a Contribution on A Seventh-Century Pottery Group." *DOP* 22:195-216.
- Harvey, A. 1989. *Economic Expansion of the Byzantine Empire 900-1200*. Cambridge: Cambridge University Press.
- Hayes, J. W. 1992. *Excavations at Saraçhane in Istanbul. Vol. 2, The Pottery*. Princeton: Princeton University Press.
- Hendy, M. F. 1985. *Studies in the Byzantine Monetary Economy c. 300-1450*. Cambridge: Cambridge University Press.
- Hocker, F. M. 1998. "Bozburun Byzantine Shipwreck Excavation: The Final Campaign 1998." *INA Quarterly* 25.4:3-13.
- Hocker, F. M. 2004a. "Shipbuilding: Philosophy, Practice, and Research." In *The Philosophy of Shipbuilding: Conceptual Approaches to the Study of Wooden Ships*, edited by F. M. Hocker and C. A. Ward, 1-11. College Station: Texas A&M University Press.
- Hocker, F. M. 2004b. "Bottom-Based Shipbuilding in Northwestern Europe." In *The Philosophy of Shipbuilding: Conceptual Approaches to the Study of Wooden Ships*,

- edited by F. M. Hocker and C. A. Ward, 65-94. College Station: Texas A&M University Press.
- Höckmann, O. 1993. "Late Roman Rhine Vessels from Mainz, Germany." *IJNA* 22: 125-35.
- Höckmann, O. 1997. "The Liburnian: Some Observations and Insights." *IJNA* 26: 192-216.
- Holland, H. 1815. *Travels in the Ionian Isles, Albania, Thessaly, Macedonia, etc, during the years 1812 and 1813*. London: Longman, Hurst, Rees, Orme, and Brow.
- Horden, P. and N. Purcell, eds. 2020. *The Boundless Sea: Writing Mediterranean History*. London and New York: Routledge.
- Horden, P. and N. Purcell. 2000. *The Corrupting Sea: A Study of Mediterranean History*. Oxford: Blackwell.
- Horden, P. and N. Purcell. 2020. "The Boundless Sea of Unlikeness?: On Defining the Mediterranean." In *The Boundless Sea: Writing Mediterranean History*, edited by P. Horden and N. Purcell, 42-60. London and New York: Routledge.
- Howard-Johnston, J. D. 1995. "The Siege of Constantinople in 626." In *Constantinople and Its Hinterland*, edited by C. Mango and G. Dagron, 131-42. Aldershot: Variorum.
- Howard-Johnston, J. D. 2010. *Witnesses to a World Crisis: Historians and Histories of the Middle East in the Seventh Century*. Oxford: Oxford University Press.
- Hughes, J. D. 1983. "How the Ancients Viewed Deforestation." *JFA* 10:435-445.
- Hughes, J. D. 2005. *The Mediterranean: An Environmental History*. California, Colorado, England: ABC-CLIO.
- Hughes, J. D. and J. V. Thirgood. 1982. "Deforestation, Erosion, and Forest Management in Ancient Greece and Rome." *Journal of Forest History* 26.2:60-75.
- Ingram, R. 2018. "The Hull of Yenikapı Shipwreck YK 11: A 7th-Century Merchant Vessel from Constantinople's Theodosian Harbour." *IJNA* 47.1:103-39.
- Insoll, T. 2007. *Archaeology: The Conceptual Challenge*. London: Duckworth.

- Irwin, M. E. 2016. "Greek and Roman Botany." In *A Companion to Science, Technology, and Medicine in Ancient Greece And Rome*, edited by G. L. Irby, 265-80. Chichester, UK; Hoboken, NJ: John Wiley & Sons.
- Israeli, E. and Y. Kahanov. 2014. "The 7th-9th Century Tantura E Shipwreck, Israel: construction and reconstruction." *IJNA* 43.2:369–88.
- Izdebski, A. 2012. "The Changing Landscapes of Byzantine Northern Anatolia," *Archaeologia Bulgarica*, 15:47-66.
- Izdebski, A. 2013. *A Rural Economy in Transition: Asia Minor from the End of Antiquity into the Early Middle Ages*. Warsaw: Taubenschlag Foundation.
- Izdebski, A. and M. Mulryan, eds. 2018. *Environment and Society in the Long Late Antiquity*. London, Boston: Brill.
- Izdebski, A., J. Pickett, N. Roberts, and T. Waliszewski. 2015. "The environmental, archaeological and historical evidence for regional climatic changes and their societal impacts in the Eastern Mediterranean in Late Antiquity." *Quaternary Science Reviews* 136:1-20.
- Jacoby, D. 1998. "What Do We Learn about Byzantine Asia Minor from the Documents of the Cairo Genizah?" In *Byzantine Asia Minor (6th-12th centuries)*, edited by N. Oikonomides and S. Vryonis, 83-95. Athens: National Hellenic Research Foundation.
- Jacoby, D. 2000. "Byzantine Trade with Egypt From the Mid-Tenth Century to the Fourth Crusade." *Θησαυρίσματα/Thesaurismata* 30:25-75.
- Jacoby, D. 2001. "The supply of war materials to Egypt in the Crusader period." *Jerusalem Studies in Arabic and Islam* 25:102-32.
- Jacoby, D. 2004. "Venetian Commercial Expansion in the Eastern Mediterranean, 8th–11th centuries." In *Byzantine Trade, 4th-12th Centuries: The Archaeology of Local, Regional and International Exchange. Papers of the Thirty-eighth Spring Symposium of Byzantine Studies, St John's College, University of Oxford, March 2004*, edited by M. M. Mango, 371-91. Farnham: Ashgate.
- Jacoby, D. 2017. "Byzantine Maritime Trade, 1025–1118." *TravMém* 21:627-48.
- Jankowiak, M. 2013. "The First Arab Siege of Constantinople." *TravMém* 17:237-320.

- Janssen, E., J. Poblome, J. Claeys, V. Kint, P. Degryse, E. Marinova, B. Muys. 2017. "Fuel for Debating Ancient Economies. Calculating Wood Consumption at Urban Scale in Roman Imperial Times." *JAS: Reports* 11:592–9.
- Jeffreys, E., J. Haldon and R. Cormack, eds. 2008. *The Oxford Handbook of Byzantine Studies*. Oxford: Oxford University Press.
- Jones, A. H. M. 1964. *The Later Roman Empire 284-602: A Social Economic and Administrative Survey*, Vols. 1-2. Norman: University of Oklahoma Press.
- Jones, M. R. 2017. "The Hull Construction of Yenikapı 14 (YK 14), A Middle Byzantine Shipwreck from Constantinople's Theodosian Harbour, Istanbul, Turkey." *IJNA* 46.2:253–83.
- Kahanov, Y. 2000. "Tantura B Shipwreck: a preliminary report on its hull construction." In *Down the River to the Sea: Proceedings of the Ninth International Symposium on Boat and Ship Archaeology*, Gdańsk 1997, edited by J. Litwin, 151–54. Gdańsk: Polish Maritime Museum.
- Kahanov, Y. 2001. The Byzantine shipwreck ("Tantura A") in Tantura Lagoon, Israel: Hull Construction Report. In *Tropis VI: Proceedings of the 6th International Symposium on Ship Construction in Antiquity, Lamia, 1996*, edited by H. Tzalas, 265–71. Athens: Hellenic Institute for the Preservation of Nautical Tradition.
- Kahanov, Y. 2003. "Dor D Wreck, Tantura Lagoon Israel." In *Boats, Ships, and Shipyards: Proceedings of the Ninth International Symposium on Boat and Ship Archaeology, Venice 2000 (ISBSA 9)*, edited by C. Beltrame, 49-56. Oxford: Oxbow Books.
- Kahanov, Y. 2011. "Shipwrecks from Dor (Tantura) Lagoon: their contribution to the 'transition in construction.'" *Skyllis* 11.1:46-50.
- Kahanov, Y., and H. Mor. 2006. "The Dor 2001/1 wreck, Dor/Tantura Lagoon, Israel: Preliminary Report." In *Connected by the Sea: Proceedings of the Tenth International Symposium on Boat and Ship Archaeology, Roskilde 2003 (ISBSA 10)*, edited by L. Blue, F. Hocker, and A. Englebert, 84-8. Oxford: Oxbow Books.
- Kahanov, Y., and H. Mor. 2014. "The Dor 2001/1 Byzantine shipwreck, Israel. Final report." *IJNA* 43.1:41-65.

- Kahanov, Y., and J. G. Royal. 2001. "Analysis of Hull Remains of the Dor D Vessel, Tantura, Israel." *IJNA* 30.2:257-65.
- Kahanov, Y., and S. Breitstein. 1995. "Preliminary Study of the Hull Remains, *INA Quarterly* 22.2:9-13.
- Kahanov, Y., J. Royal, and J. Hall. 2004. "The Tantura Wrecks and Ancient Mediterranean Shipbuilding." In *The Philosophy of Shipbuilding. Conceptual Approaches to the Study of Wooden Ships*, edited by F. M. Hocker and C. A. Ward, 113-29. College Station: Texas A&M University Press.
- Kaldellis, A. 2015. *Byzantine Readings of Ancient Historians: Texts in Translation, with Introductions and Notes*. London and New York: Routledge.
- Kaldellis, A. 2017. *Streams of Gold, Rivers of Blood: The Rise and Fall of Byzantium, 955 AD to the First Crusade*. Oxford: Oxford University Press.
- Kalligas, C. 1990. *Byzantine Monemvasia: The Sources*. Oxford: Oxbow.
- Karathanasis, K. 2019. "A Game of Timber Monopoly: Atheno-Macedonian Relations on the Eve of the Peloponnesian War." *Hesperia* 88:707-726.
- Kassianidou, V. 2013. "Mining Landscapes of Prehistoric Cyprus." *Metalla* 20.2:36-45.
- Khalilieh, H. S. 2005. "The Enigma of Tantura B: Historical Documentation and the Lack of Circumstantial Documentary Evidence." *IJNA* 34.2:314-22.
- Kislinger, E. 2019. "9.8. Commercial travel." In *Brill's New Pauly Supplements II - Volume 10 : History and Culture of Byzantium*, edited by J. N. Dillon, 337-39. Stuttgart: Springer-Verlag.
- Kleinhenz, C. 2004. *Medieval Italy: An Encyclopedia*. New York and London: Routledge.
- Kocabaş, U. 2012a. "Byzantine Shipwrecks at Yenikapı." In *Between Continents: Proceedings of the Twelfth Symposium on Boat and Ship Archaeology, Istanbul 2009 (ISBSA 12)*, edited by N. Günsenin, 107-14. Istanbul: Ege Yayınları.
- Kocabaş, U. 2012b. "The Latest Link in the Long Tradition of Maritime Archaeology in Turkey: The Yenikapı Shipwrecks." *EJA* 15.2: 309-23.

- Kocabaş, U. 2015. "The Yenikapı Byzantine-era Shipwrecks, Istanbul, Turkey: A Preliminary Report and Inventory of the 27 Wrecks Studied by Istanbul University." *IJNA* 44.1:5-38.
- Kocabaş, U., ed. 2008. *The 'Old Ships' of the 'New Gate.'* Istanbul: Ege Yayınları.
- Koder J. 1994. "Historical Aspects of a Recession of Cultivated Land at the End of the Late Antiquity in the East Mediterranean." In *Evaluation of Land Surfaces Cleared from Forests in the Mediterranean Region during the Time of the Roman Empire, Paleoclimate Research 10*, edited by B. Frenzel, L. Reisch, and M. M. Weiss 157–67. Stuttgart: Fischer.
- Kuniholm, P. I. 1982. "Dendrochronology of the Keel." In *Yassı Ada: A Seventh-Century Shipwreck*. Volume I, by G. F. Bass and F. H. van Doorninck, 326-27. College Station, TX: Texas A&M University Press.
- Kuniholm, P. I. 2001. "Dendrochronology and Other Applications of Tree-ring Studies in Archaeology." In *Handbook of Archaeological Sciences*, edited by D. R. Brothwell and A. M. Pollard, 35-46. London: John Wiley & Sons.
- Kuniholm, P. I. 2008. "Dendrochronology". In *Oxford Handbook of Byzantine Studies*, edited by E. Jeffreys, J.F. Haldon, and R. Cormack, 182-92. Oxford: Oxford University Press.
- Kuniholm, P. I., C. B. Griggs, and M. W. Newton. 2007. "Evidence for Early Timber Trade." In *Byzantina Mediterranea. Festschrift für Johannes Koder zum 65. Geburtstag*, edited by K. Belke, E. Kislinger, A. Külzer, and M. A. Stassinopoulou, 365-85. Vienna: Böhlau.
- Kuniholm, P. I., C. L. Pearson, T. J. Wazny, and C. B. Griggs. 2015. "Of Harbors and Trees: The Marmaray Contribution to a 2367-Year Oak- Tree-Ring Chronology from 97 Sites for the Aegean, East Mediterranean, and Black Seas." In *Istanbul and Water*, edited by P. Magdalino and N. Ergin, 45–90. Leuven: Peeters
- Kuniholm, P.I., and C. L. Striker. 1987. "Dendrochronological Investigations in the Aegean and Neighboring Regions, 1983-1986," *JFA* 14:385-98.

- Kuniholm, P.I., and C. L. Striker. 1990. "Dendrochronology and the Architectural History of the Church of the Holy Apostles in Thessaloniki," *Architectura: Zeitschrift für Geschichte der Architektur* 2:1-26.
- Kurul, E. 2014. "Rhodosluların Denizcilik Yasası: Nomos Rhodion Nautikos." *Cedrus: Akdeniz Uygarlıkları Araştırma Dergisi* 2:527-49.
- Kyprouli, V. .2017. "Boat F of Pisa (Italy)." In *Ships and Maritime Landscapes: Proceedings of the Thirteenth International Symposium on Boat and Ship Archaeology, Amsterdam 2012*, edited by J. Gawronski, A. van Holk, and J. Schokkenbroek, 460-5. Eelde: Barkhuis.
- Laiou, A. E. 2002. "Writing the Economic History of Byzantium." In *The Economic History of Byzantium from the Seventh Through the Fifteenth Century*, edited by A. E. Laiou, 1-8. Dumbarton Oaks Series No. 39. Washington, DC: Dumbarton Oaks.
- Laiou, A. E. 2005. "The Byzantine village (5th-14th century)." In *Les villages dans l'Empire byzantin IVe-IXe siècle*. Edited by J Lefort, C. Morrisson and J-P Sodini, 31-54. Paris: Lethielleux.
- Leake, W. M. 1826. *An Edict of Diocletian Fixing A Maximum of Prices Throughout the Roman Empire*. London: John Murray.
- Leidwanger, J. 2017. "From Time Capsules to Networks: New Light on Roman Shipwrecks in the Maritime Economy." *AJA* 121.4: 595-619.
- Leidwanger, J. 2020. *Roman Seas*. New York: Oxford University Press.
- Lev-Yadun, S. 1992. "The Origin of the Cedar Beams from Al-Aqsa Mosque: Botanical, Historical and Archaeological Evidence" *Levant* 24.1:201-08.
- Lev-Yadun, S. 2007. "Wood remains from archaeological excavations: A review with a Near Eastern perspective." *Israel Journal of Earth Sciences* 56: 139-62.
- Lewis, A. R. 1951. *Naval Power and Trade in the Mediterranean, AD 500-1100*. Princeton: Princeton University Press.
- Liddell, H. G. and R, Scott. 1897. *A Greek-English Lexicon*. New York: American Book Company.

- Linder, E. 1986. "The Khorsabad Wall Relief: A Mediterranean Seascape or River Transport of Timbers?" *JAOS* 106.2:273-81.
- Liphschitz, N. 1998. "The Arboreal Vegetational Landscape of Sinai During Antiquity as Evident from Archaeological Wood Remains." *Israel Journal of Plant Sciences* 46.1:53-9.
- Liphschitz, N. 2009. "Kyrenia and Ma'agan Mikhael Shipwrecks: A comparative dendroarchaeological study." *Skyllis* 9.1:18-21.
- Liphschitz, N. 2012a. "Dendroarchaeology of shipwrecks in Israel." *BOCCONEA* 24:95-104.
- Liphschitz, N. 2012b. The use of Lebanese Cedar for ship construction as evident from timber identification of shipwrecks in the East Mediterranean. *Skyllis* 12:94-8.
- Liphschitz, N. 2013. Cedars of Lebanon. *BAR* 39:49-56,71.
- Liphschitz, N. 2014a. "*Platanus orientalis* (Oriental Plane) as a hull construction timber: Yenikapı Byzantine galleys." *Skyllis* 14.1:84-5.
- Liphschitz, N. 2014b. "Three Yassı Ada Wrecks: A comparative dendroarchaeological investigation." *Skyllis* 14.2:203-07.
- Liphschitz, N. and C. Pulak. 2007/2008. "Wood Species Used in Ancient Shipbuilding in Turkey: Evidence from Dendroarchaeological Studies." *Skyllis* 1.2:73-82.
- Liphschitz, N. and C. Pulak. 2009. "Shipwrecks of the Portus Theodosiacus. Types of Wood Used in Some Byzantine Roundships and Longships found at Yenikapı, Istanbul." *Skyllis* 9.2:164-71.
- Liphschitz, N. and G. Biger. 2001. "Past distribution of Aleppo pine (*Pinus halepensis*) in the mountains of Israel (Palestine)." *The Holocene* 11.4:427-36.
- Loewen, B. 2000. "Forestry Practices and Hull Design, ca. 1400-1700." In *Fernando Oliveira and his Era: Humanism and the Art of Navigation in Renaissance Europe (1450- 1650)*, edited by I. Guerreiro, 143-51. Cascais: Patrimonia.
- Lombard, M. 1959a. "Arsenaux et bois de marine dans la Méditerranée musulmane, VIIe-XIe s" In *Le navire et l'économie maritime du Moyen-Age au XVIII^e siècle principalement en Méditerranée* (Travaux du Deuxième Colloque International

- d'histoire maritime tenu, les 17 et 18 mai 1957, à l'Académie de Marine.), edited by M. Mollat, 53-106. Paris: S.E.V.P.E.N.
- Lombard, M. 1959b. "Un problème cartographié: le bois dans la Méditerranée musulmane (VII e-XI e siècles)." *Annales. Histoire, Sciences Sociales*, 14:234-54.
- Lorentzen, B., S. Manning and Y. Kahanov. 2014. "The 1st Millennium AD Mediterranean Shipbuilding Transition at Dor/ Tantura Lagoon, Israel: Dating the Dor 2001/1 Shipwreck." *Radiocarbon* 56.2:1-12.
- Loveluck, C. 2013. *Northwest Europe in the early middle ages, c. AD 600–1150: a comparative archaeology*. Cambridge: Cambridge University Press.
- Magdalino, P. 2013. "The Harbours of Byzantine Constantinople," In *Stories of the Hidden Harbour: Shipwrecks of Yenikapı*, edited by Z. Kızıltan and G. Baran-Çelik, 11-5. Istanbul: Istanbul Archaeological Museums Press.
- Makris, G. 2002. "Ships", In *The Economic History of Byzantium from the Seventh Through the Fifteenth Century*, edited by A. E. Laiou, 91-100. Dumbarton Oaks Series No. 39, Vol. 1-3. Washington, DC: Dumbarton Oaks.
- Matschke, K-P. 2001. "Builders and Building in Late Byzantine Constantinople" In *Byzantine Constantinople: Monuments, Topography and Everyday Life*, edited by N. Necipoğlu, 315-28. Leiden, Boston, Köln: Brill.
- Matthews, S. D. and J. R. Steffy. 2004. "The hull remains." In *Serçe Limanı: A Eleventh-Century Shipwreck. Vol 1, The Ship and Its Anchorage, Crew, and Passengers*, by G. F. Bass, S. D. Matthews, J. R. Steffy, and F. H. van Doorninck, 81-122. College Station: Texas A&M University Press.
- McCormick, M. 2001. *Origins of the European Economy: Communications and Commerce AD 300-900*. Cambridge: Cambridge University Press.
- McCormick, M. 2012. "Movements and Markets in the First Millennium Information, Containers, and Shipwrecks." In *Trade and Markets in Byzantium*, edited by C. Morrisson, 51-98. Washington: Dumbarton Oaks Research Library and Collection. .
- McGrail, S. 1989. "Maritime archaeology in Britain." *Antiq. Journal*, 69.1:10-22.

- McGrail, S. 1997. "Early Frame-First Methods of Building Wooden Boats and Ships." *Mariner's Mirror* 83.4:76-80.
- McGrail, S. 2002. *Boats of the World*. Oxford: Oxford University Press.
- McGrail, S. 2015. "Hornell, Hasslof and boatbuilding sequences." *IJNA* 44.2:382-7.
- Meiggs, R. 1980. "Sea-Borne Timber Supplies to Rome." *MAAR* 36:185–96.
- Meiggs, R. 1982. *Trees and Timber in the Ancient Mediterranean World*. Oxford: Oxford University Press.
- Meijer, F. 2014. *A History of Seafaring in the Classical World*. Routledge Revivals. Oxon: Routledge.
- Mikesell, M. W. 1969. "The Deforestation of Mount Lebanon." *Geographical Review* 59:1-28.
- Mikhail, A. 2017. *Under Osman's Tree: The Ottoman Empire, Egypt, and Environmental History*. Chicago: University of Chicago Press.
- Miklosich, F. and Müller, J. 2012. *Acta et Diplomata Graeca Medii Aevi Sacra et Profana. Vol. 3, Acta et Diplomata Graeca Res Graecas Italasque Illustrantia*. Cambridge: Cambridge University Press.
- Mitford, T. B. 1980. "Roman Rough Cilicia." In *Aufstieg und Niedergang der Römischen Welt - Politische Geschichte (Provinzen und Randvölker: Griechischer Balkanraum; Kleinasien)*, edited by H. Temporini, 1230-1261. Berlin & New York: Walter de Gruyter & Co.
- Mor, H. 2010. "The Dor 2001/1 Shipwreck: Hull Construction Report." In *Transferts technologiques en architecture navale Méditerranéenne de l'antiquité aux temps Modernes: identité technique et identité culturelle. Actes de la Table Ronde d'Istanbul, 19-22 mai 2007*, edited by P. Pomey, 87-95. *Varia Anatolica XX*. Paris: De Boccard/Institut Français D'Etudes Anatoliennes George- Dumezil.
- Mor, H. 2012. "The Socio-Economic Implications for Ship Construction: Evidence from Underwater Archaeology and the Codex Theodosianus." In *Shipping, Trade, and Crusade in the Medieval Mediterranean: Studies in Honor of John Pryor*, edited by R. Gertwagen and E. Jeffreys, 39-64. Burlington: Ashgate.

- Morrison, J. S., J. F. Coates, and N. B. Rankov. 2000. *The Athenian Trireme. The History and Reconstruction of an Ancient Greek Warship*. Cambridge: Cambridge University Press.
- Morrison, J., and J. F. Coates. 1996. *Greek and Roman Oared Warships*. Oxford: Oxbow.
- Morrisson, C. 2016. "Trading in Wood in Byzantium: Exchange and Regulations." In *Trade in Byzantium: Papers from the Third International Sevgi Gönül Byzantine Studies Symposium, Istanbul*, edited by N. Necipoğlu and P. Magdalino, 105-127. Istanbul: ANAMED.
- Muckelroy, K. 1998. "Introducing Maritime Archaeology" In *Maritime Archaeology, A Reader of Substantive and Theoretical Contributions* edited by L. E. Babits and H. van Tilburg, 23-38. New York: Springer Science+Business Media.
- Murray, W. M. 1991. "Classification of the Athlit Ship: A Preliminary Report" In *The Athlit Ram*, edited by L. Casson and J.R. Steffy, 72-5. College Station: Texas A&M University Press.
- Murray, W. M., and P. M. Petsas. 1988. "The Spoils of Actium." *Archaeology* 41: 28-35.
- Muys, Bart. 2019. "Meet the Trees of Sagalassos." In *Meanwhile in the Mountains: Sagalassos*, edited by J. Poblome and F. Yalçinkaya, 257-66. Istanbul: Yapı Kredi Yayınları.
- Navri, R., Y. Kahanov and D. Cvikel. 2014. The Byzantine-Period Dor 2006 Shipwreck, Israel: preliminary hull construction report. *IJNA* 43.1:41-65.
- Nayling, N. and J. Susperregi. 2014. "Iberian Dendrochronology and the Newport Medieval Ship." *IJNA* 43.2: 279-91.
- Nicol, D. M. 1988. *Venice and Byzantium: A Study in Diplomatic and Cultural Relations*. Cambridge: Cambridge University Press.
- Nicol, D. M. 1993. *The Last Centuries of Byzantium (1261-1453)*. Cambridge: Cambridge University Press.
- Niewöhner, P. ed., 2017. *The Archaeology of Byzantine Anatolia: From the End of Late Antiquity Until the Coming of the Turks*. Oxford: Oxford University Press.

- Orengo, A. H., J. M. Palet, A. Ejarque, Y. Miras and S. Riera. 2013. "Pitch Production During the Roman Period: An Intensive Mountain Industry For A Globalised Economy?" *Antiquity*, 87:802-14.
- Ousterhout R. 2019. *Eastern Medieval Architecture*. Oxford: Oxford University Press.
- Özdaş, H. 2007. "Ege ve Akdeniz Bölgeleri Sualtı Araştırması 2005 Yılı Çalışmaları." *Araştırma Sonuçları Toplantısı* 24.2: 433-50.
- Özdaş, H. 2009a. "Akdeniz Bölgesi Sualtı Araştırması 2007 Yılı Çalışmaları." *Araştırma Sonuçları Toplantısı* 26.3: 259-72.
- Özdaş, H. 2009b. "Ege Bölgesi Sualtı Araştırması 2007 Yılı Çalışmaları." *Araştırma Sonuçları Toplantısı* 26.3: 249-58.
- Özdaş, H. 2010. "Ege- Akdeniz Bölgesi Sualtı Araştırması 2008 Yılı Çalışmaları." *Araştırma Sonuçları Toplantısı* 27.1: 433-52.
- Özdaş, H., N. Kızıldağ, and E. Okan. 2012. "Ege- Akdeniz Bölgesi Sualtı Araştırması 2010 Yılı Çalışmaları." *Araştırma Sonuçları Toplantısı* 29.2: 267-80.
- Özsait-Kocabaş, I. 2018. "The Yenikapı 12 Shipwreck, a 9th-Century Merchantman from the Theodosian Harbour in Istanbul, Turkey: construction and reconstruction." *IJNA* 47.2:357-90.
- Papacostas, T. 1999. "Byzantine Cyprus: The Testimony of its Churches 650–1200", Ph.D.diss., University of Oxford.
- Parker, A.J. 1992. *Ancient Shipwrecks of the Mediterranean and the Roman Provinces*. BAR-IS 580. Oxford: Tempus Reparatum.
- Pearson, C. L., C. B. Griggs, P. I. Kuniholm, P. W. Brewer, T. Wazny, and L. Canady. 2012. "Dendroarchaeology of the mid-first millennium AD in Constantinople." *JAS* 39.11:3402-414.
- Perrot, G., E. Guillaume and J. Delbet. 1862. *Exploration archeologique de la Galatie et de la Bithynie : d'une partie de la Mysie, de la Phrygie, de la Cappadoce et du Pont*. Paris: Librairie de Firmin Didot Freres.

- Pierre Gilles. 2007. *Itinéraires byzantins. Lettre a un ami. Du Bosphore de Thrace. Da le topographie de Constantinople et de ses antiquités*. Translated by J.P. Gréolois. Paris: Association des amis du Centre d'histoire et civilisation de Byzance.
- Pirenne, H. 2008. *Mohammed and Charlemagne*. London and New York: Routledge.
- Pomey, P. 2004. "Principles and Methods of Construction in Ancient Naval Architecture." In *The Philosophy of Shipbuilding: Conceptual Approaches to the Study of Wooden Ships*, edited by F. M. Hocker and C. A. Ward, 25-36. College Station: Texas A&M University Press.
- Pomey, P. 2011. "Defining a Ship: Architecture, Function, and Human Space." In *The Oxford Handbook of Maritime Archaeology*, edited by A. Catsambis, D. L. Hamilton, and B. Ford, 25-46. Oxford: Oxford University Press.
- Pomey, P., and E. Rieth. 2005. *L'archéologie navale*. Paris: Errance.
- Pomey, P., Y. Kahanov, and E. Rieth. 2012. "Transition from Shell to Skeleton in Ancient Mediterranean Ship-Construction: Analysis, Problems, and Future Research." *IJNA* 41.2:235-314.
- Pryor, J. H. 1992. *Geography, Technology, and War: Studies in the Maritime History of the Mediterranean, 649-1571*. Cambridge: Cambridge University Press.
- Pryor, J. H. 2002. "Types of Ships and their Performance Capabilities." In *Travel in the Byzantine World*, edited by R. Macrides, 33-58. Society for the Promotion of Byzantine Studies Publications 10. Aldershot: Ashgate.
- Pryor, J. H. 2008. "Shipping and Seafaring." In *The Oxford Handbook of Byzantine Studies*, edited by E. Jeffreys, with J. Haldon and R. Cormack, 482-91. Oxford: Oxford University Press.
- Pryor, J. H. and E. M. Jeffreys. 2006. *The Age of the ΔΡΟΜΩΝ: The Byzantine Navy ca 500, 1204*. Leiden, Boston: Brill.
- Pulak, C. 1998. "The Uluburun Shipwreck: an overview." *IJNA* 27.3:188-224.
- Pulak, C. 2002. "The Uluburun Hull Remains." In *Tropis VII: Proceedings of the 7th International Symposium on Ship Construction in Antiquity, Pylos, 1999*, edited by H. Tzalas, 615-36. Athens: Hellenic Institute for the Preservation of Nautical Tradition.

- Pulak, C. 2007. "Yenikapı Byzantine Shipwrecks." In *Istanbul: 8,000 Years Brought to Daylight: Marmaray, Metro, Sultanahmet Excavations*, edited by Z. Kızıltan, 202-15. Istanbul, Turkey: Vehbi Koç Vakfı.
- Pulak, C. 2018. "Yenikapı Shipwrecks and Byzantine Shipbuilding." *TravMém* 22:237-95.
- Pulak, C., R. Ingram and M. Jones. 2015. "Eight Byzantine Shipwrecks from the Theodosian Harbour Excavations at Yenikapı in Istanbul, Turkey: An Introduction." *IJNA* 44.1:39-73.
- Rainey, A. F. 2015. *The El-Amarna Correspondence (2 vol. set)*. Leiden: Brill.
- Rankov, B. 1995. "Fleets of the Early Roman Empire, 31 BC-324 AD." In *The Age of the Galley: Mediterranean Oared Vessels since pre-Classical Times* edited by R. Gardiner and J.S. Morrison, 78-85. Conway's History of the Ship. Annapolis, Md.: Naval Institute Press.
- Redford, S. 2014. *Legends of Authority: The 1215 Seljuk Inscriptions of Sinop Citadel, Turkey*. Istanbul: Koç University Press.
- Rich, S. 2016. "Shiver Me Timbers! No Cedar Ships in the Medieval Mediterranean?" In *Interoceanic Canals and World Seaborne Trade: Past, Present and Future, Royal Academy for Overseas Sciences International Colloquium, Brussels, 7-9 June 2012*, edited by J. Charlier, C. De Meyer and H. Paelinck, 71-82. Brussels: Koninklijke Academie voor Overzeese Wetenschappen.
- Rich, S., S. W. Manning, P. Degryse, F. Vanhaecke, K. Latruwe, K. Van Lerberghe. 2016. "To put a Cedar Ship in a Bottle: Dendroprovenancing three ancient East Mediterranean watercraft with the $^{87}\text{Sr}/^{86}\text{Sr}$ isotope ratio." *JAS: Reports* 9:514-21.
- Rich, S., S. W. Manning, P. Degryse, F. Vanhaecke, K. Van Lerberghe. 2012. "Strontium isotopic and tree-ring signatures of *Cedrus brevifolia* in Cyprus" *J. Anal. At. Spectrom* 27:796-806.
- Rich, S., S.W. Manning, P. Degryse, F. Vanhaecke, and K. Van Lerberghe. 2016. "Provenancing East Mediterranean cedar wood with the $^{87}\text{Sr}/^{86}\text{Sr}$ strontium isotope ratio." *Archaeological and Anthropological Sciences* 8.3:467-76.

- Rival, M. 1991. *La Charpenterie Navale Romaine*. Paris: Editions du Centre National de la Recherche Scientifique.
- Roberts, N. 2018. Revisiting the Beyşehir Occupation Phase: Land-Cover Change and the Rural Economy in the Eastern Mediterranean During the First Millennium AD, *Late Antique Archaeology*, 11(1), 53-68.
- Rotman, Y. 2009. *Byzantine Slavery and the Mediterranean World*. Cambridge: Harvard University Press.
- Rotman, Y. 2016. Byzantium and the International Slave Trade in the Central Middle Ages. In *Trade in Byzantium: Papers from the Third International Sevgi Gönül Byzantine Studies Symposium, Istanbul*, edited by N. Necipoğlu and P. Magdalino, 129-142. Istanbul: ANAMED.
- Royal, J. and Y. Kahanov. 2000. An Arab-period merchant vessel at Tantura Lagoon, Israel (Trench 9). *IJNA* 29:1, 151-3.
- Russell, B. 2013. *The Economics of the Roman Stone Trade*. Oxford: Oxford University Press.
- Schibille, N. 2009. The Profession of The Architect in Late Antique Byzantium *Byzantion* 79:360-79.
- Schilbach, E. 1970. *Byzantinische Metrologie*. Munich: C.H. Beck.
- Schweingruber, F. H. 1988. *Tree Rings, Basics and Applications of Dendrochronology*. Dordrecht, Boston and London: Kluwer Academic Publishers.
- Schweingruber, F. H. 1993. *Trees and Wood in Dendrochronology, Morphological, Anatomical, and Tree-Ring Analytical Characteristics of Trees Frequently Used in Dendrochronology*. Berlin: Springer-Verlag.
- Smith, C. A.W. 1851. *A New Classical Dictionary of Greek And Roman Biography, Mythology, And Geography Partly Based Upon The Dictionary Of Greek And Roman Biography And Mythology*. New York: Harper & Bros.
- Sowada, K. N. 2009. *Egypt in the Eastern Mediterranean during the Old Kingdom: An Archaeological Perspective*. Fribourg, Switzerland / Göttingen, Germany: Academic Press / Vandenhoeck Ruprecht.

- Steffy, J. R. 1982a. "Reconstructing the Hull." In *Yassı Ada: A Seventh-Century Byzantine Shipwreck*. Volume I, by G. F. Bass and F. H. van Doorninck, 65-86. College Station, TX: Texas A&M University Press.
- Steffy, J. R. 1982b. "The Reconstruction of the 11th century Serçe Liman Vessel. A Preliminary Report." *IJNA* 11.1:13-34.
- Steffy, J. R. 1985. "The Kyrenia Ship: An Interim Report on its Hull Construction." *AJA* 89.1:71-101.
- Steffy, J. R. 1990. "The Boat: A Preliminary Study of its Construction." In *The Excavation of an Ancient Boat in the Sea of Galilee, (Lake Kinneret)* edited by S. Wachsmann, 29-48. Jerusalem: The Israel Antiquities Authority.
- Steffy, J. R. 1991. "The Ram and Bow Timbers: A Structural Interpretation" In *The Athlit Ram*, edited by L. Casson and J.R. Steffy, 6-31. College Station: Texas A&M University Press.
- Steffy, J. R. 1994. *Wooden Shipbuilding and the Interpretation of Shipwrecks*. College Station: Texas A & M University Press.
- Steffy, J. R. 1995. "Ancient Scantlings: The Projection and Control of Mediterranean Hull Shapes." In *Tropis III, Third International Symposium on Ship Construction in Antiquity, Athens, 24-28 August 1989*, edited by H. Tzalas, 417-28. Athens, Greece: Hellenic Institute for the Preservation of Nautical Tradition.
- Steffy, J. R. 1998. "Seldom discussed features of ancient and medieval ship construction." *Archaeonautica* 14:165-9.
- Steffy, J. R. 2004. "Construction and analysis of the vessel" In *Serçe Limanı: A Eleventh-Century Shipwreck. Vol 1, The Ship and Its Anchorage, Crew, and Passengers*, by G. F. Bass, S. D. Matthews, J. R. Steffy, and F. H. van Doorninck, 153-69. College Station: Texas A&M University Press.
- Steffy, J. R. 2011. "Illustrated Glossary of Ship and Boat Terms." In *The Oxford Handbook of Maritime Archaeology*, edited by A. Catsambis, D. L. Hamilton, and B. Ford, 1106-50. Oxford: Oxford University Press.

- Steinhauer, G. 1998. *The Monuments and Archaeological Museum of Piraeus*. Koropi: M. Toubis.
- Stephen W. Reinert, S. W. 1998. "The Muslim Presence in Constantinople, 9th-15th Centuries: Some Preliminary Observations." In *Studies on the Internal Diaspora of the Byzantine Empire*, edited by H. Ahrweiler and A. E. Laiou, 125-50. Washington: Dumbarton Oaks.
- Tafel, G. and G. Thomas. 1856. *Urkunden zur älteren Handels- und Staatsgeschichte der Republik Venedig mit besonderer Beziehung auf Byzanz und die Levante, Vol. III*. Vienna: K.K. Hof- und Staats-Druckerei.
- Terpstra, T. T. 2013. *Trading Communities in The Roman World: A Micro-Economic and Institutional Perspective*. Leiden and Boston: Brill.
- Thirgood, J. V. 1981. *Man and the Mediterranean Forest: A History of Resource Depletion*. London, New York: Academic Press.
- Thonemann, P. 2011. *The Maeander Valley: A Historical Geography from Antiquity to Byzantium*. Cambridge: Cambridge University Press.
- Touwaide, A. 2020. "Botany". In *A Companion to Byzantine Science*, edited by S. Lazaris, 302-53. Leiden: Brill.
- Treadgold, W. 1997. *A History of the Byzantine State and Society*. Stanford: Stanford University Press.
- Tusa, S., and J. Royal. 2012. The Landscape of the Naval Battle at the Egadi Islands. *JRA* 25:7-49.
- Ulrich, R. B. 2007. *Roman Woodworking*. New Haven and London: Yale University Press.
- Unger, R. W. 1980. *Ship in the Medieval Economy 600-1600*. Montreal: McGill-Queen's University Press.
- Unger, R. W. 1981. "Warships and Cargo Ships in Medieval Europe." *Technology and Culture* 22.2:233-52.
- Unger, R. W. 2015. "Commerce, Communication, and Empire: Economy, Technology and Cultural Encounters." *Speculum* 90.1:1-27.

- Van Doorninck, F. H. 1993. Did Tenth-Century Dromons Have a Waterline Ram?" *The Mariner's Mirror*, 79.4:387-92.
- Van Doorninck, F. H. 1976. "The 4th century wreck at Yassı Ada. An interim report on the hull." *IJNA* 5:115-31.
- Van Doorninck, F. H. 1982. "The Hull Remains." In *Yassı Ada: A Seventh-Century Shipwreck*. Volume I, edited by G. F. Bass and F. H. van Doorninck, 32-64. College Station: Texas A&M University Press.
- Van Doorninck, F. H. 2002a. "Byzantine Shipwrecks." In *The Economic History of Byzantium: from the Seventh to the Fifteenth Century*, vol. 3, edited by A. E. Laiou, 899-905. Dumbarton Oaks Series No. 39. Washington, DC: Dumbarton Oaks Research Library and Collection.
- Van Doorninck, F. H. 2002b. "The Byzantine Ship at Serçe Limanı: an Example of Small-Scale Maritime Commerce with Fatimid Syria in the Early Eleventh Century." In *Travel in the Byzantine World*, edited by R. Macrides, 137-48. Society for the Promotion of Byzantine Studies Publications 10. Aldershot: Ashgate Publishing, Ltd.
- Van Doorninck, F. H. 2012. "Ethnicity and Sphere of Activity of the Crew of the 11th-Century Serçe Limanı Ship: Some Tentative Observations." In *Between Continents: Proceedings of the Twelfth Symposium on Boat and Ship Archaeology, Istanbul 2009 (ISBSA 12)*, edited by N. Günsenin, 127-33. Istanbul: Ege Yayınları.
- Van Doorninck, F. H. 2015. "The Seventh-Century Byzantine Ship at Yassıada and Her Final Voyage: Present Thoughts." In *Maritime Studies in the Wake of the Byzantine Shipwreck at Yassıada, Turkey*, edited by D. N. Carlson, S. M. Kampbell, J. Leidwanger, and G. F. Bass, 205-16. College Station: Texas A&M University Press.
- Van Duivenvoorde, W. 2012. "Use of Pine Sheathing on Dutch East India Company Ships." In *Between Continents: Proceedings of the Twelfth Symposium on Boat and Ship Archaeology, Istanbul 2009 (ISBSA 12)*, edited by N. Günsenin, 241-51. Istanbul: Ege Yayınları.
- Veal, R. 2013. "Fuelling Ancient Mediterranean Cities: A Framework for Charcoal Research." In *The Ancient Mediterranean Environment Between Science and History*, edited by W.V. Harris, 37-61. Leiden, Boston: Brill.

- Veal, R. 2017. "The Politics and Economics of Ancient Forests: Timber and Fuel as Levers of Greco-Roman Control." In *Economie et inégalité: Ressources, échanges et pouvoir dans l'Antiquité Classique*, edited by S. von Reden, 317-67. Geneva: Fondation Hardt.
- Veal, R. 2019. "The History and Science of Fire and Fuel in the Roman Empire" In *Fuel and Fire in the Ancient Roman World: Towards an integrated economic understanding*, edited by R. Veal and V. Leitch, 11-24. Cambridge: McDonald Institute for Archaeological Research.
- Verboven, K. 2016. "Guilds and the Organisation of Urban Populations During the Principate." In *Work, Labour, and Professions in the Roman World*, edited by K. Verboven and C. Laes, 173 -202. Leiden, Boston: Brill.
- Vermoere, M., S. Six, J. Poblome, P. Degryse, E. Paulissien, M. Waelkens and E. Smets. 2003. "Pollen Sequences from the City of Sagalassos (Pisidia, Southwest Turkey)." *Anatolian Studies* 53:161-73.
- Votruba, G. F. 2017. "Did vessels beach in the ancient Mediterranean? An assessment of the textual and visual evidence." *The Mariner's Mirror* 103.1:7-29.
- Vroom, J. 2016. "Byzantine Sea Trade in Ceramics: Some Case Studies in the Eastern Mediterranean (ca. Seventh-Fourteenth Centuries)." In *Trade in Byzantium. Papers from the Third International Sevgi Gönül Byzantine Studies Symposium*, edited by P. Magdalino and N. Necipoglu, 157-77. Istanbul: ANAMED.
- Wachsmann, S. 1990 "Conslusions." In *The Excavation of an Ancient Boat in the Sea of Galilee, (Lake Kinneret)* edited by S. Wachsmann, 131-34. Jerusalem: The Israel Antiquities Authority.
- Wachsmann, S. 2000. *The Sea of Galilee Boat*. Cambridge: Perseus Publishing.
- Wachsmann, S. 2001. "The INA/CMS Joint Expedition to Tantura Lagoon, Israel: Report on the 1994-1995 Seasons of Excavation." In *Tropis VI: Proceedings of the 6th International Symposium on Ship Construction in Antiquity, Lamia, 1996*, edited by H. Tzalas, 601-03. Athens: Hellenic Institute for the Preservation of Nautical Tradition.

- Wachsmann, S., and Y. Kahanov. 1997. "Shipwreck Fall: The 1995 INA/CMS Joint Expedition to Tantura Lagoon, Israel." *INA Quarterly* 24.1:3-18.
- Wachsmann, S., Y. Kahanov, and J. Hall. 1997. "The Tantura B Shipwreck: The 1996 INA/CMS Joint Expedition to Tantura Lagoon." *INA Quarterly* 24.4:13.
- Waliszewski, T. 2001. "Mosaics." In *The Petra Church*, edited by Z. T. Fiema, C. Kanellopoulos, T. Waliszewski and R. Schick, 219-70. Amman: ACOR Publications.
- Ward, C. 2012. "Building pharaoh's ships: Cedar, incense and sailing the Great Green." *British Museum Studies in Ancient Egypt and Sudan* 18:217-32.
- Wazny, T. 2009. "Is there a separate tree-ring pattern for Mediterranean oak?" In *Tree-Rings, Kings, and Old World Archaeology and Environment: Papers Presented in Honor of Peter Ian Kuniholm*, edited by S. W. Manning and M. J. Bruce, 41-50. Oxford: Oxbow.
- Wazny, T., P. I. Kuniholm and C. L. Pearson. 2017. "Dendrochronology of the Early Byzantine fort at Capidava" In *Capidava II: Building C1: Contributions to the History of Annona Militaris in the 6th Century*, edited by I. C. Opriş and A. Raţiu, 175-81. Cluj-Napoca: Mega Publishing House.
- Whitewright, J. 2016. "Ships and Boats." In *A Companion to Science, Technology, and Medicine in Ancient Greece And Rome*, edited by G. L. Irby, 870-88. Chichester, UK; Hoboken, NJ: John Wiley & Sons.
- Whittow, M. 1996. *The Making of Byzantium, 600-1025*. Berkeley: University of California Press.
- Wilkinson, T. A. H. 2000. "*Royal Annals of Ancient Egypt: The Palermo Stone and Its Associated Fragments.*" London and New York: Kegan Paul International
- Wilson, A.I. 2012. "Raw Materials and Energy." In *The Cambridge Companion to the Roman Economy*, edited by W. Scheidel, 133-55. Cambridge: Cambridge University Press.
- Xoplaki, E., D. Fleitmann, J. Luterbacher, S. Wagner, J. F. Haldon, E. Zorita, I. Telelis, A. Toreti, A. Izdebski. 2015. "The Medieval Climate Anomaly and Byzantium: A

review of the evidence on climatic fluctuations, economic performance and societal change.” *Quaternary Science Reviews* 136: 1-24.

Zavagno, L. 2017. *Cyprus between the Late Antiquity and the Early Middle Ages (ca.600-ca.850 A.D), An Island in Transition*. London: Routledge.

Zucker, A. 2020. “Zoology”. In *A Companion to Byzantine Science*, edited by S. Lazaris, 261-301. Leiden: Brill.

Zuckerman, C. 2005. “Learning from the Enemy and More: Studies in “Dark Centuries” of Byzantium.” *Millennium* 2:79-135.

Zwick, D. 2013. “Conceptual Evolution in Ancient Shipbuilding: An Attempt to Reinvigorate A Shunned Theoretical Framework.” In *Interpreting Shipwrecks: Maritime Archaeology Approaches* edited by J. Adams and J. Rönby, 46-71. Southampton: Highfield Press.

APPENDIX A: LIST OF TREE SPECIES IN THIS THESIS (LATIN-ENGLISH-TURKISH)

SPECIES		
Latin	English	Turkish
<i>Abies alba</i>	Silver fir	Orta Avrupa göknarı
<i>Abies borisii-regis</i>	Bulgarian fir	Bulgaristan göknarı
<i>Abies cephalonica</i>	Greek fir	Yunanistan göknarı
<i>Abies cilicica</i>	Taurus fir	Toros göknarı
<i>Abies nordmanniana</i>	Caucasian fir	Karadeniz göknarı
<i>Acer pseudoplatanus</i>	Sycamore maple	Dağ akçaağacı
<i>Carpinus betulus</i>	Common hornbeam	Adi gürgen
<i>Carpinus orientalis</i>	Oriental hornbeam	Doğu gürgeni
<i>Castanea sativa</i>	Anatolian chestnut	Anadolu keşanesi
<i>Cedrus atlantica</i>	Atlas cedar	Atlas sediri
<i>Cedrus brevifolia</i>	Cyprus cedar	Kıbrıs sediri
<i>Cedrus libani</i>	Taurus cedar	Toros sediri
<i>Cornus mas</i>	Cornelian cherry	Kızılcık
<i>Cupressus sempervirens</i>	Mediterranean cypress	Akdeniz servisi
<i>Fagus orientalis</i>	Oriental beech	Doğu kayını
<i>Fagus sylvatica</i>	European beech	Avrupa kayını
<i>Fraxinus angustifolia</i>	Narrow-leaved ash	Sivri meyveli dişbudak
<i>Fraxinus excelsior</i>	European ash	Avrupa dişbudağı
<i>Fraxinus ornus</i>	Manna-ash	Çiçekli dişbudak
<i>Juglans regia</i>	Common walnut	Adi ceviz
<i>Juniperus oxycedrus</i>	Prickly juniper	Katran ardıcı
<i>Larix decidua</i>	European larch	Avrupa melezi
<i>Olea europaea</i>	Olive	Zeytin
<i>Pinus brutia</i>	Turkish pine	Kızılcık
<i>Pinus halepensis</i>	Aleppo pine	Halep çamı
<i>Pinus nigra</i>	Black pine	Karaçam
<i>Pinus pinaster</i>	Maritime pine	Sahil çamı
<i>Pinus pinea</i>	Stone pine	Fıstıkçamı

<i>Platanus orientalis</i>	Oriental plane	Doğu çınarı
<i>Quercus cerris</i>	Turkey oak	Saçlı meşe
<i>Quercus coccifera</i>	kermes oak	Kermes meşesi
<i>Quercus ilex</i>	holly oak or holm oak	Pırnal meşe
<i>Quercus petraea</i>	Sessile oak	Sapsız meşe
<i>Quercus pontica</i>	Pontine oak	Doğu Karadeniz meşesi
<i>Spartium junceum</i>	Spanish broom	Katırtırnağı
<i>Tamarix smyrnensis</i>	Smyrna tamarisk	İzmir ılgını
<i>Ulmus glabra</i>	Mountain elm	Dağ karaağacı
<i>Ulmus minor</i>	Field elm	Ova karaağacı
<i>Ziziphus spina Christi</i>	Christ's thorn jujube	Dikenli hünnap

APPENDIX B: DISTRIBUTION OF SELECTED TREE SPECIES⁸¹⁵

Latin	App. Altitude⁸¹⁶ and Size⁸¹⁷	Distribution	Qualities
<i>Abies alba</i>	300–1700 m	Europe: From the Pyrenees to the Carpathians, Italy (Apennines) and in the Balkan Peninsula to Bulgaria and N Greece. ⁸¹⁸	straight, columnar trunk, grows taller in humid forests; often used for masts, grows better as natural forest rather than plantation; easy to work but non-durable.
	55-60 m, d.b.h. to 2–2.5 m		
<i>Abies borisii-regis</i>	800–1800 m	S Albania, Bulgaria (Rhodope Mts.), Greece (Macedonia to N Peloponnesus) ⁸¹⁹	straight, columnar trunk, similar to European fir (<i>Abies alba</i>) in all its properties and uses.
	40 m, d.b.h. to 1.5 m		
<i>Abies cephalonica</i>	900–1700 m	Greece (Cephalonia, Euboea, Sterea Hellas, Peloponnesus). ⁸²⁰	straight trunk; but is found very rarely.
	30-35 m, d.b.h. 1.5–2 m		
<i>Abies cilicica</i>	800–2100 m	Lebanon, Syria, Turkey (Anti-Taurus, Cilician Taurus). ⁸²¹	straight, columnar trunk, exploited from native forests, not suitable for cultivation.
	30 m, d.b.h. 0.75–1 m		
<i>Abies nordmanniana</i>	900–2200 m	Caucasus Mts, N Anatolia (Paphlagonia). ⁸²²	straight, columnar trunk, needs high precipitation.
	50 m, d.b.h. 1.5–2 m		

⁸¹⁵ Compiled from Farjon 2017; Davis 1967, 1970, 1972, 1978, 1982. Abbreviations are as: N: North, S: South, E: East, W: West, C: Central, Mts: mountains.

⁸¹⁶ The altitudes change with the climate, approximations are given for comparative purposes.

⁸¹⁷ Average sizes. Length in meters (m) and diameter at breast height (d.b.h) in meters (m) respectively.

⁸¹⁸ Farjon 2017, 62.

⁸¹⁹ Farjon 2017, 68.

⁸²⁰ Farjon 2017, 71.

⁸²¹ Farjon 2017, 74.

⁸²² Farjon 2017, 111.

Latin	App. Altitude ⁸¹⁶ and Size ⁸¹⁷	Distribution	Qualities
<i>Acer pseudoplatanus</i>	0–1500 m	Most of Europe, W Caucasia, Thrace, N Anatolia. ⁸²³	straight trunk, massive low branches; easy to work but prone to decay.
	30–35 m, d.b.h. 0.6–1.5 m		
<i>Carpinus betulus</i>	0–1000 m	N Anatolia, Caucasia. ⁸²⁴	very hard wood, but decays fast and is difficult to work with; coppiced and pollarded for firewood.
	15–25 m, d.b.h. 0.6–1 m		
<i>Carpinus orientalis</i>	0–1200 m	N and S Anatolia, SE Europe (Balkans) ⁸²⁵	
	1–10 m, d.b.h. 0.6–0.8 m		
<i>Castanea sativa</i>	30–1500 m	N Anatolia, W Anatolia, C Greece, Caucasia. ⁸²⁶	trunk straight with branching at low heights; very durable, easy to work with but prone to splits
	30–37 m, d.b.h. 1.5–2.0 m		
<i>Cedrus atlantica</i>	1370–2200 m	NW Africa: Algeria, Morocco (Atlas Mts.). ⁸²⁷	trunk usually straight, columnar, massive; first order branches massive; used in Northern Africa.
	30–35 m, d.b.h. 1.5–2 m		
<i>Cedrus brevifolia</i>	900–1525 m	Cyprus, Troodos Mountains, Mt. Triphylos. ⁸²⁸	very similar to <i>Cedrus libani</i> , but endemic to the island of Cyprus.
	15–20 m, d.b.h. 1–1.2 m		
<i>Cedrus libani</i>	1100–3000 m	Lebanon, Syria (Djebel el Ansiriya), Turkey (Taurus and Anti-Taurus Mts., disjunct in northern Turkey). ⁸²⁹	monopodial, columnar, massive, often forked or branched below 1/3 of the bole; first order of branches massive; resistant to decay and easy to work.
	35–40 m, d.b.h. 1.5–2.5 m		

⁸²³ Davis 1967:2, 511.⁸²⁴ Davis 1967:2, 511.⁸²⁵ Davis 1982:7, 684–5.⁸²⁶ Davis 1982:7, 659.⁸²⁷ Farjon 2017, 262.⁸²⁸ Farjon 2017, 267.⁸²⁹ Farjon 2017, 267.

Latin	App. Altitude ⁸¹⁶ and Size ⁸¹⁷	Distribution	Qualities
<i>Cornus mas</i>	0–1000 m	N Turkey, S Anatolia, Islands, C and SE Europe, Crimea. ⁸³⁰	small and shrub like; dense, shock resistant.
	5–12 m, d.b.h. 0.3–0.4 m		
<i>Cupressus sempervirens</i>	90–1700 m	E Mediterranean: Crete, Cyprus, East Aegean Is., Greece; N Africa: Libya, Tunisia; Western Asia: Iran, Israel, Jordan, Lebanon, Syria, and Anatolia. ⁸³¹	straight trunk; durability and resistance to decay, suitable for carving.
	40 m, d.b.h. 2 m		
<i>Fagus orientalis</i>	500–2100 m	N Anatolia; NW and S Anatolia. ⁸³²	strength, durability, and versatility
	45 m, d.b.h. 3 m		
<i>Fagus sylvatica</i>	700–2100 m	W and C Europe, Balkans, S. Russia. ⁸³³	non-durable, perishable
	30–40 m, d.b.h. 1–1.5 m		
<i>Fraxinus angustifolia</i>	0–1700 m	Mostly W, S and C Anatolia, C and S Europe, SW Asia. ⁸³⁴	similar but inferior to <i>Fraxinus excelsior</i> in strength
	20–30 m, d.b.h. 1.5 m		
<i>Fraxinus excelsior</i>	0–1700 m	Most of Europe, SW Asia, and N Anatolia. ⁸³⁵	not very durable, but is hard, elastic and resistant to splinters.
	20–35 m, d.b.h. 1–2 m		
<i>Fraxinus ornus</i>	0–500 m	NW, W Anatolia, Italy, Greece, S Europe. ⁸³⁶	has small and poorly shaped trunks
	15–25 m, d.b.h. 1 m		

⁸³⁰ Davis 1972:4, 541.⁸³¹ Farjon 2017, 323.⁸³² Davis 1982:7, 657–58.⁸³³ Davis 1982:7, 658.⁸³⁴ Davis 1978:6, 150–55.⁸³⁵ Davis 1978:6, 149–51.⁸³⁶ Davis 1978:6, 148–49.

Latin	App. Altitude ⁸¹⁶ and Size ⁸¹⁷	Distribution	Qualities
<i>Juglans regia</i>	0–2000 m	(presumably) native in NE and E Anatolia, Balkans, Lebanon, Caucasus, N. Iraq, Iran, Afghanistan. ⁸³⁷	very durable and easy to work with.
	25–35 m, d.b.h. 2 m		
<i>Juniperus oxycedrus</i>	0–1600 m	Mediterranean Region, around the Black Sea and Middle East: Albania, Algeria, Bosnia-Herzegovina, Bulgaria, Caucasus, Croatia, Cyprus, France, Greece, Iran (Azerbaijan), Iraq, Israel, Italy, Jordan, Lebanon, Libya, Macedonia, Malta, Morocco, Portugal, Romania, Serbia, Spain, Syria, Transcaucasia, Tunisia, Turkey, Crimea. ⁸³⁸	found usually in shrublands and dry woodlands; resin is used extensively.
	10 m, d.b.h. 0.5–1 m		
<i>Larix decidua</i>	1000–2200 m	Europe: Alps, Carpathians, Slovakian Mts., S Poland. ⁸³⁹	straight trunk; needs cool, moist summers; very durable
	40–55m, d.b.h 1.5–2.5 m		

⁸³⁷ Davis 1978:6, 654.⁸³⁸ Farjon 2017, 445.⁸³⁹ Farjon 2017, 499.

Latin	App. Altitude ⁸¹⁶ and Size ⁸¹⁷	Distribution	Qualities
<i>Olea europaea</i>	0–1000 m	Mediterranean coasts except NE Africa. ⁸⁴⁰	easy to work
	8–15 m, d.b.h. 1.0–1.5 m		
<i>Pinus brutia</i>	0–1500 m	E Mediterranean Region; around the Black Sea; Caucasus; Turkey; NW Iran; N Iraq. ⁸⁴¹	straight trunk, regenerates after fire by seed dispersal, easiest pine to grow, tapped for resin.
	30 m, d.b.h. 1.5 m		
<i>Pinus halepensis</i>	0–1700 m	Mediterranean, from Morocco and Portugal to Greece and the coast of Libya at Jabal al Akhdar, and in Israel, Jordan, Lebanon, SW Syria. ⁸⁴²	straight, curved or sinuous; not very useful as timber but is used for firewood, rich in resin.
	20 m, d.b.h. 0.8 m		
<i>Pinus nigra</i>	250–1,600 m	SW, S and SE Europe; N Algeria; N Morocco; Cyprus; Turkey; Crimea along the Black Sea coast eastwards to Krasnodar in the Caucasus. ⁸⁴³	monopodial but sometimes with multiple stems from a low basal trunk; moderately resistant to rot, easy to work with.
	40 m, d.b.h. 1.5 m		
<i>Pinus pinaster</i>	0–600 m	SW and S Europe; N Africa, Morocco, border between Algeria and Tunisia. ⁸⁴⁴	trunk straight or curved, branches long; moderately resistant to rot but sometimes hard to work due to excessive resin.
	30 m, d.b.h. 1.5 m		

⁸⁴⁰ Davis 1978:6, 155–6.⁸⁴¹ Davis 1978:6, 155–6.⁸⁴² Farjon 2017, 703.⁸⁴³ Farjon 2017, 744.⁸⁴⁴ Farjon 2017, 757.

Latin	App. Altitude ⁸¹⁶ and Size ⁸¹⁷	Distribution	Qualities
<i>Pinus pinea</i>	0–600 m	Mediterranean Europe and Near East (cultivated). ⁸⁴⁵	monopodial or soon forked into more stems.
	20–25 m, d.b.h. 1 m		
<i>Platanus orientalis</i>	0–2000 m	Balkans, Crete, W Syria, N Iraq, Iran, Greece, Anatolian coasts. ⁸⁴⁶	spreading crown, thus various curvatures are present
	30 m, d.b.h. 3 m		
<i>Quercus cerris</i>	200–1500 m	S Europe, all of Anatolia except for the NE and E; Syria and Lebanon. ⁸⁴⁷	mid-durable against rotting, very fast growing but has a tendency to crack and is of low quality
	25–37 m, d.b.h. 1.2–2.0 m		
<i>Quercus coccifera</i>	0–1000 m	Widespread in the Mediterranean region except NE Africa. ⁸⁴⁸	very hard wood
	1–6 m, d.b.h. 0.5 m		
<i>Quercus ilex</i>	0–1300 m	NW, W, and S Anatolia, widespread in N Mediterranean but scattered in N and W Anatolia, Aegean Islands, Istanbul. ⁸⁴⁹	resistant to rot, suitable for boatbuilding
	20–25 m, d.b.h. 1–1.2 m		
<i>Quercus petraea</i>	0–1600 m	Most of Europe, Balkans, NW Anatolia. ⁸⁵⁰	very resistant to decay, suitable for boatbuilding
	24–35 m, d.b.h. 1–1.5 m		
<i>Quercus pontica</i>	1300–2100 m	NE Anatolia, W Caucasus mountains and Armenia. ⁸⁵¹	
	6–10 m, d.b.h. 0.4 cm		

⁸⁴⁵ Farjon 2017, 760.⁸⁴⁶ Davis: 1982:7, 656.⁸⁴⁷ Davis 1982:7, 674–76.⁸⁴⁸ Davis 1982:7, 674–76.⁸⁴⁹ Davis 1982:7, 680.⁸⁵⁰ Davis 1982:7, 667–68.⁸⁵¹ Davis 1982:7, 662.

Latin	App. Altitude ⁸¹⁶ and Size ⁸¹⁷	Distribution	Qualities
<i>Spartium junceum</i>	0–600 m	N, W, S Anatolia (coasts) and Aegean islands, S Europe, Crimea, W Syria, N Africa. ⁸⁵²	shrub
	2–4 m, d.b.h. 0.05 m		
<i>Tamarix smyrnensis</i>	0–1000 m	İzmir, Antalya, Caucasia, Iran, N Iraq, Transcaspian, Afghanistan, Balkans, W Syria, Romania, Crimea. ⁸⁵³	shrub.
	4–15m, bush.		
<i>Ulmus glabra</i>	0–1500 m	Mostly found in the Euro Siberian climate, scattered around Anatolia except C and S.E., Europe, Caucasia, N Iran. ⁸⁵⁴	not very easy to work but holds well after steaming.
	20–40 m, d.b.h. 0.6–1.2 m		
<i>Ulmus minor</i>	0–1000 m	W Turkey, Thrace, and the Aegean islands. ⁸⁵⁵	
	20–40 m, d.b.h. 1–2m		
<i>Ziziphus spina Christi</i>	0–1500 m	Originates from Sudan, mostly N Africa and the Near East. ⁸⁵⁶	
	15–23 m, d.b.h. 0.45 m		

⁸⁵² Davis 1970:3, 32.⁸⁵³ Davis 1967:2, 349.⁸⁵⁴ Davis 1982:7, 645.⁸⁵⁵ Davis 1982:7, 647.⁸⁵⁶ Dafni et al. 2005.

APPENDIX C: GLOSSARY OF NAUTICAL TERMS⁸⁵⁷

Ballast. Heavy material, such as iron, lead, or stone, placed low in the hold to lower the center of gravity and improve stability.

Beam. A timber mounted athwartships to support decks and provide lateral strength; large beams were sometimes called baulks.

Bow. The forward part of a hull, specifically, from the point where the sides curve inward to the stem.

Butt. The lateral end of a hull plank or timber.

Butt joint. The union of two planks or timbers whose ends were cut perpendicularly to their lengths; sometimes called carvel joint.

Cathead. A beam, or crane, projecting from the bow and used for hoisting the anchor clear of the bow after it had surfaced

Caulk [Calk]. To drive oakum, moss, animal hair, or other fibrous material into the seams of planking and cover it with pitch to make the seams watertight.

Ceiling. The internal planking of a vessel.

Coak. A rectangular or cylindrical pin let into the ends or seams of timbers about to be joined in order to align or strengthen the union.

Compass timber [Compassing]. Naturally curved timbers used for frames and construction in the ends of a hull.

Copper fastened. A vessel whose fastenings were made of copper.

Crossbeam. A substantial timber placed across a pair of bitts.

Cutwater. The forwardmost part of the stem; the stem piece or nosing that parts the water.

Deadrise. The amount of elevation, or rising, of the floor above the horizontal plane; the difference between the height of the bilge and the height of the keel rabbet.

Diagonal framing. Frames or riders placed diagonally over the regular frames or ceiling to provide additional stiffening to a hull.

Double framing. A general term signifying frames composed of two rows of overlapping futtocks.

Dowel [Dowel pin]. A cylindrical piece of wood (of constant diameter) used to align two members by being sunk into each. A cylindrical coak. Unlike treenails and pegs, dowels

⁸⁵⁷ The terms are taken from the *Illustrated Glossary of Ship and Boat Terms* first published by Steffy in *Wooden Ship Building and the Interpretation of Shipwrecks* in 1994, 266-98 and republished in the *The Oxford Handbook of Maritime Archaeology* in 2011.

served an alignment function only, additional fastenings being necessary to prevent separation of the joint.

False keel [Shoe]. A plank, timber, or timbers attached to the bottom of the keel to protect it in the event of grounding or hauling; on large ships, false keels were sometimes made quite thick in order to increase the size and strength of the keel.

False stem. An outer timber fixed to the forward surface of the stem to strengthen or protect it, or to provide better symmetry to the cutwater. Also, a name sometimes given to the apron in English documents.

False sternpost. A member attached to the after surface of the sternpost to reinforce or protect it

Floor. The bottom of a vessel between the upward turns of its bilges.

Floor timber. A frame timber that crossed the keel and spanned the bottom; the central piece of a compound frame.

Frame. A transverse timber, or line or assembly of timbers, that described the body shape of a vessel and to which the planking and ceiling were fastened. Frames were sometimes called timbers or, erroneously, ribs. Ancient ships often had frames composed of lines of unconnected timbers; later ships usually had compound frames composed of floor timbers, futtocks, and top timbers. Square frames were those set perpendicular to the keel; in the bow and stern there were cant frames, running obliquely to the keel. Forward of the cant frames and fayed to them, in large round-bowed vessels, were the frames running parallel to the keel and stem, sometimes called knuckle timbers; more accurately, these were the hawse pieces and knight heads, the latter being the frames adjacent to the apron or stem-son that extended above the deck to form bitts and support the bowsprit. The aftermost frames were the fashion pieces, which shaped the stern.

Futtock. A frame timber other than a floor timber, half-frame, or top timber; one of the middle pieces of a frame.

Galley. A seagoing vessel propelled primarily by oars, but usually one that also could be sailed when necessary. Also, a name given to a vessel's kitchen.

Garboard strake [Garboard]. The strake of planking next to the keel; the lowest plank. Also, the lowest side strake of a flat-bottomed hull.

Half beam. A beam extending from the side to a hatch or other obstruction.

Half-frame. A frame whose heel began at or near one side of the keel or deadwood and spanned part or all of that side of the hull; half-frames normally were used in pairs.

Hog [Hogging]. The strain on a hull that causes its ends to droop.

Inner stempost. The inner timber or timbers of a double-layered stem; unlike an apron, an inner stempost ends at the keel-stem scarf.

Inner sternpost. A vertical timber attached to the forward surface of the sternpost to increase its strength, and in some cases, to support the transoms.

Intermediate timbers. Those individual timbers installed between the sequential frames for additional localized strength. They could span part of the bottom, turn of the bilge, or side. The term applies primarily to ancient ships and inshore craft, where they reinforced the areas around beams, mast steps, bilge sumps, etc., or extended upward as frames for bulkheads and weather screens.

Keel. The main longitudinal timber of most hulls, upon which the frames, deadwoods, and ends of the hull were mounted; the backbone of the hull.

Keel plank [Central plank, Kingplank]. A central hull plank that was substantially thicker than the rest of the bottom planking and whose breadth was at least twice as great as its thickness; a thick bottom plank used in lieu of a keel.

Keelson [Kelson]. An internal longitudinal timber or line of timbers, mounted atop the frames along the centerline of the keel, that provided additional longitudinal strength to the bottom of the hull; an internal keel. Most commonly, a single keelson was installed that was no larger than the keel. On very large vessels, however, various combinations of as many as a dozen keelsons were assembled. Where extra molding was required, one or more additional keelsons, called rider keelsons or false keelsons, were bolted to the top of the main keelson. They could be of identical size to, or smaller than, the main keelson. Auxiliary keelsons bolted alongside the main keelson were known as *sister* (U.S.), *side*, *auxiliary*, or *assistant keelsons*. However, care should be exercised in interpreting the various keelsons from contracts. For instance, some nineteenth-century American contracts for large schooners refer to the keelson above the main keelson as the sister, and the one above that as the assistant sister keelson. On occasion, large square timbers were placed at the floor head line or near the bilge, usually above the bilge keels. These were called bilge keelsons or, in some British document, sister keelsons. Secondary keelsons did not necessarily run the full length of the hull, terminating at the ends of the hold, the last square frames, or some other appropriate location.

Knee [Knee timber]. An angular piece of timber used to reinforce the junction of two surfaces of different planes; usually made from the crotch of a tree where two large branches intersected, or where a branch or root joined the trunk.

Main. In shipbuilding, the adjective applied to the most important timbers, or those having the greatest cross-sectional area; thus, on ancient vessels the main wale was usually the lowest and largest, while on later warships it was the one below the gunports; also, main breadth, main hatch, main hold, main keelson, etc.

Main frame. A term sometimes applied to frames composed of two rows of futtocks to distinguish them from filling frames, the single-rowed frames placed between them; it applies to larger vessels of the last few centuries. The term was also used infrequently to denote the midship frame.

Mast. A tall upright post on a boat carrying a sail or sails.

Mast step. A mortise cut into the top of a keelson or large floor timber, or a mortised wooden block or assembly of blocks mounted on the floor timbers or keelson, into which the tenoned heel of a mast was seated.

Midship [Midships]. A contraction of amidships and consequently, in a general sense, it refers to the middle of the ship. In construction, however, it is often used as an adjective referring to the broadest part of the hull, wherever it may be.

Midship beam. The longest beam in a vessel, located at or near the midship bend.

Midship bend. The broadest part of the hull; the widest body shape, formed by the centerline of the midship frame.

Midship flat [Midship body, Midsection, Midship section]. The extent of the broadest part of the hull, formed by the midship frame and all adjacent frames of the same breadth.

Midship frame. The broadest frame in the hull; the frame representing the midship shape on the body plan.

Mold [Mould]. A pattern used to determine the shapes of frames and other compass timbers. Molds were usually made from thin, flexible pieces of wood. Convex molds were called *bend molds*, concave molds were known as *hollow molds*, and *compound* or *reverse molds* included entire frame shapes. The degree of bevel and other pertinent information was written on the molds. The process of shaping outer frame surfaces with molds was known as beveling.

Mortise. A cavity cut into a timber to receive a tenon. Large mortises were sometimes referred to as *steps*.

Mortise-and-tenon joint. A union of planks or timbers by which a projecting piece (tenon) was fitted into one or more cavities (mortises) of corresponding size. The most common types are:

Fixed tenon and single mortise. A tenon was shaped from the end on one timber and inserted into the mortise of the other. When the tenon of a large vertical timber was left unlocked, as in masts, and sternposts, it was said to be stepped.

Free tenon and two mortises. The most common method of edge-joining planking in ancient and early medieval vessels in the Mediterranean area, it also was used to secure adjoining surfaces of parallel timbers, such as stems and floor timber chocks. Corresponding mortises were cut into each planking edge; a single hardwood tenon was inserted into the lower plank and the adjacent plank fitted over the protruding tenon. In many instances, the joint was locked by driving tapered hardwood pegs into holes drilled near each strake or timber edge.

Free tenon and three or more mortises. Used in superstructure fabrications or places where hull planking was too narrow to provide sufficient seating for the desired tenon length.

Although small planking joints whose tenons are unpegged and contribute no structural strength are essentially coak joints, the term mortise-and-tenon joint has become universally accepted for all such forms of edge joinery.

Oakum [Oakham]. Caulking material made from rope junk, old rope, and rope scraps; it was unwound, picked apart, and the fibers were rolled and soaked in pitch before being driven into planking seams.

Oar port. An opening in a vessel's side through which the looms of oars or sweeps passed.

Outboard. Situated near or on the outer side of a vessel; toward the outer side.

Peg [Tenon peg]. A tapered wooden pin driven into a pre-drilled hole to fasten two members or lock a joint. Pegs came in a variety of sizes and tapers; they could have square, round, or multi-sided cross sections. The important difference between dowels and pegs in ancient construction was that the former were of constant diameter and lightly set, while the latter were tapered and driven with appreciable force. The most common use of pegs in ancient construction was the locking of mortise-and-tenon joints.

Planking. The outer lining, or shell, of a hull.

Planking strake [Strake, Streak]. A continuous line of planks, usually running from bow to stern; the sum of a row of planks

Port [Port side, Larboard]. The left side of a vessel when facing forward.

Rabbet. A groove or cut made in a piece of timber in such a way that the edges of another piece could be fit into it to make a tight joint. Generally, the term refers to the grooves cut into the sides of the keel, stem, and sternpost, into which the garboards and hooding ends of the outer planking were seated.

Ram. A strong projection on the bow of an ancient warship, usually sheathed in metal, used as a weapon to strike another vessel. Specifically, the ram included the ramming timber, the forward bow timbers configured to reinforce the ramming timber, and a metal sheath; in actual practice, the metal sheath is usually called the ram. Rams were also used, with little success, on iron warships after the middle of the nineteenth century.

Rudder. A timber, or assembly of timbers, that could be rotated about an axis to control the direction of a vessel underway. Until the middle of the medieval period, the practice was to mount rudders on one or both stern quarters; these were known as *quarter rudders*. By the late medieval period, however, it appears that most vessels of appreciable size were steered by a single rudder hung at the sternpost; these were known as *stern-hung rudders*. For a brief period, the two types were sometimes used in combination. Rudders were designed for the vessel and type of duty they served. In protected waters they could be made quite broad, while seagoing ships utilized longer, more narrow rudders. For the largest seagoing ships, rudder construction was complex and required huge timbers, the assembly sometimes weighing several tons

Sag [Sagging]. The accidental rocker formed in a keel and bottom due to insufficient timbering or improper loading.

Scantlings. The principal timbers of a vessel.

Scarf [Scarph]. An overlapping joint used to connect two timbers or planks without increasing their dimensions.

Seam. The longitudinal joint between two timbers or planks; the term usually refers to planking seams, the longitudinal juxtaposition of the edges of planks in the sides or decks, which were made watertight.

Sheathing. A thin covering of metal or wood, to protect hulls from marine life or fouling, or to stabilize and protect surface material applied for that purpose. Sheathing was most

commonly used in the form of copper, lead, zinc, or alloy sheets, or thin wooden planks known as *furring* or *deals*.

Sheer. The longitudinal sweep of a vessel's sides or decks.

Shell. The external planking of a vessel.

Shell-first construction [Shell-built]. A modern (sometimes misleading) term used to describe the process by which all or part of the outer hull planking was erected before frames were attached to it. In pure shell-built hulls, outer planking was self-supporting and formed the primary structure; the framework fastened to it formed the secondary, or stiffening, structure.

Shipwright. A master craftsman skilled in the construction and repair of ships. In many instances, the person in charge of a ship's construction, including the supervision of carpenters and other personnel, control of expenditures and schedules, and acquisition of materials. Probably in many more areas and periods than have been documented, the term designated a formal title, such as the shipwrights to the English monarchs, or a level of expertise qualifying admission to a guild or association.

Skeletal construction [Frame-first construction]. A modern (sometimes misleading) term used to describe the procedure in which hulls were constructed by first erecting frames and then attaching the outer skin of planking to them.

Starboard. The right side of a vessel when facing forward.

Stem [Stempost]. A vertical or upward curving timber or assembly of timbers, scarfed to the keel or central plank at its lower end, into which the two sides of the bow were joined.

Stemson. A curved timber mounted on the inner surface of the apron; usually, the forward and upward extension of the keelson.

Stern. The after end of a vessel.

Sternpost. A vertical or upward-curving timber or assembly of timbers stepped into, or scarfed to, the after end of the keel or heel.

Sternson. A curved timber joining the keelson and inner sternpost; usually an extension of the keelson and was mounted on top of the deadwood.

Stringer [Longitudinal]. A general term describing the longitudinal timbers fixed to the inside surfaces of the frames; the ceiling, other than the common ceiling.

Tenon. A wooden projection cut from the end of a timber or a separate wooden piece that was shaped to fit into a corresponding mortise.

Tenon-built. A term used to denote vessels whose planking edges were joined by means of mortise-and-tenon joints.

Through-beam. An athwartships timber that extended through and beyond the outer hull planking. Through-beams were most common on ancient and medieval hulls, where they supported the quarter rudders or provided athwartships stiffness to the upper part of the hull.

Thwart. A transverse plank in a boat or galley; used to seat rowers, support masts, or provide lateral stiffness.

Tiller. A wooden or metal level fitted into the rudder head, by which the rudder could be moved from side to side.

Timbers. In general context, all wooden hull members; specifically, those members that formed the frames of a hull.

Treenail [Trunnel, Trennal]. A round or multi-sided piece of hardwood, driven through planks and timbers to connect them. Treenails were employed most frequently in attaching planking to frames, attaching knees to ceiling or beams, and in the scarfing of timbers. They were used in a variety of forms: with expanding wedges or nails in their ends, with tapered or square heads on their exterior ends, or completely unwedged and unheaded. When immersed, treenails swelled to make a tight fit.

Turn of the bilge. The outboard part of the lower hull where the bottom curved toward the side.

Wale. A thick strake of planking, or a belt of thick planking strakes, located along the side of a vessel for the purpose of girding and stiffening the outer hull.

APPENDIX D: CHRONOLOGIES

Chronology of Eastern Roman Emperors⁸⁵⁸

Eastern Roman Emperors	Reign
Constantine I	324-337
Constantius II	337-361
Julian	361-363
Jovian	363-364
Valens	364-378
Theodosios I	379-395
Arkadios	395-408
Theodosios II	408-450
Marcian	450-457
Leo I	457-474
Leo II	474
Zeno	474-475
Basiliskos	475-476
Zeno (restored)	476-491
Anastasios I	491-518
Justin I	518-527
Justinian I	527-565
Justin II	565-578
Tiberios II Constantine	578-582
Maurice	582-602
Phokas	602-610
Herakleios	610-641
Constantine III and Heraklonas	641
Constans II	641-668
Constantine IV	668-685
Justinian II	685-695

⁸⁵⁸ From Jeffreys et al. 2008, 962-71.

Leontios	695-698
Tiberios III	698-705
Justinian II (restored)	705-711
Philippikos Bardanes	711-713
Anastasios II	713-715
Theodosios III	715-717
Leo III	717-741
Constantine V	741-775
Artabasdos	741-742
Leo IV	775-780
Constantine VI	780-797
Eirene	797-802
Nikephoros I	802-811
Staurakios	811
Michael I	811-813
Leo V	813-820
Michael II	820-829
Theophilos	829-842
Michael III	842-867
Basil I	867-886
Leo VI	886-912
Alexander	912-913
Constantine VII	913-959
Romanos I Lekapenos	920-944
Romanos II	959-963
Nikephoros II Phokas	963-969
John I Tzimiskes	969-976
Basil II	976-1025
Constantine VIII	1025-1028
Romanos III Argyros	1028-1034
Michael IV the Paphlagonian	1034-1041
Michael V Kalaphates	1041-1042

Zoe and Theodora	1042
Constantine IX Monomachos	1042-1055
Theodora (again)	1055-1056
Michael VI Stratiotikos	1056-1057
Isaac I Komnenos	1057-1059
Constantine X Doukas	1059-1067
Eudokia	1067
Romanos IV Diogenes	1068-1071
Eudokia (again)	1071
Michael VII Doukas	1071-1078
Nikephoros III Botaneiates	1078-1081
Alexios I Komnenos	1081-1118
John II Komnenos	1118-1143
Manuel I Komnenos	1143-1180
Alexios II Komnenos	1180-1183
Andronikos I Komnenos	1183-1185
Isaac II Angelos	1185-1195
Alexios III Angelos	1195-1203
Isaac II (restored) and Alexios IV Angelos	1203-1204
Alexios V Mourtzouphlos	1204
Constantine (XI) Laskaris	1204 (Nicaea)
Theodore I Laskaris	1204-1222 (Nicaea)
John III Doukas Vatatzes	1222-1254 (Nicaea)
Theodore II Laskaris	1254-1258 (Nicaea)
John IV Laskaris	1258-1261 (Nicaea)
Michael VIII Palaiologos	1259-1282
Andronikos II Palaiologos	1282-1328
Michael IX Palaiologos	1294-1320
Andronikos III Palaiologos	1328-1341
John V Palaiologos	1341-1391
John VI Kantakouzenos	1341-1354
Andronikos IV Palaiologos	1376-1379

John VII Palaiologos	1390
Manuel II Palaiologos	1391-1425
John VIII Palaiologos	1425-1448
Constantine XI (XII) Palaiologos	1448-1453



Chronology of Important Events in the Eastern Mediterranean⁸⁵⁹

Year	Event
312	Battle of the Milvian Bridge
324	Battle of the Hellespont
330	Constantinople inaugurated as the capital of the Eastern Roman Empire
395	Rome is divided into Eastern and Western parts
410	Sack of Rome by Visigoths
451	Fourth Ecumenical Council in Chalcedon
476	The last Roman emperor in the West is deposed
532	Nika Riots in Constantinople
535–554	The Gothic Wars
541–41	Justinianic Plague
602–628	Byzantine–Sasanian War
622	Hegira, Heraclius' Persian Campaign starts
626	Siege of Constantinople by Persians and Avars
627	Emperor Heraclius defeats the Persian army at Nineveh
636	Battle of Yarmuk
636–46	Arabs occupy Syria, Palestine and Egypt and overrun Persian Empire
640–42	Muslim conquest of Egypt
647	First Arab invasion of Asia Minor
649	Muawiya sets up the Muslim navy, attack on Cyprus
652	Temporary Muslim conquest of Cyprus
652–4	Muslim raids of Crete, Rhodes and Sicily
655	Battle of the Masts
668	Constans II dies in Sicily
674–78	First Muslim Siege of Constantinople (contested)
681	Foundation of Bulgarian state
686–88	Cyprus becomes a condominium between Muslims and the Byzantines
711	Muslims complete the conquest of North Africa
717–18	Second Muslim Siege of Constantinople
726–87	First period of Iconoclasm
750	Abbasids overthrow the Umayyads
756–75	War between Byzantium and Bulgaria
762	Baghdad is founded by Abbasid caliph al-Mansur
800	Charlemagne crowned as the Emperor in Rome
811	Nicephorus I defeated and killed by Bulgarians
813–43	Second period of Iconoclasm
827	Muslim occupation of Crete
864	Conversion of Bulgaria
912–22	War between Byzantium and Bulgaria

⁸⁵⁹ Compiled from Browning 1992, 295–6; Pryor and Jeffreys 2006, 7–122; Gregory 2010, 444–48.

961	Byzantines reconquer Crete from Muslims
990-1019	Conquest of Bulgaria by Basil II
963	Athanasios founds The Great Lavra monastery on Mount Athos
964	Byzantine dominance in Cyprus
1054	the Great Schism
1071	Battle of Manzikert
1096–1099	First Crusade
1133-43	Victorious campaigns of John I in Cilicia and Syria
1147	Second Crusade. Normans capture Corfu, Corinth, and Thebes
1176	Battle of Myriokephalon
1185	Normans capture and sack Thessalonica
1204	Capture of Constantinople by Fourth Crusade and establishment of Latin Empire
1259	Nicaean army defeats Latins and Epirotes at Pelagonia
1261	Recapture of Constantinople by Nicaean force and end of Latin Empire
1274	Council of Lyons. Michael VIII accepts Church union
c.1280	Byzantine navy disbanded
1321-28	Civil war between Andronikos II and Andronikos III
1329	Turks take Nicaea
1337	Turks take Nicomedia
1341-47	Civil war between John V and John Cantacuzenus
1354	Turks take Gallipoli
1365	Turks establish their capital at Adrianople
1387	Thessalonica surrenders to Turks
1397-1402	Siege of Constantinople by Sultan Bayezid
1422	Murad besieges Constantinople
1439	Council of Florence proclaims Church union
1453	Turks take Constantinople on 29 May. Death of last emperor