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RESEARCH ARTICLE / ARAŞTIRMA MAKALESİ

Characteristic Features and Construction Technique of Shipwreck Yenikapı 20*

Yenikapı 20 Batığının İnşa Tekniği ve Karakteristik Özellikleri

Işıl ÖZSAİT KOCABAŞ** , **Taner GÜLER*****

Abstract

During the salvage excavations carried out in the Yenikapı district of Istanbul between 2004 and 2013 within the scope of the Marmaray and Metro projects, the Theodosius Harbor, the essential commercial transportation center of Constantinople, was unearthed. Yenikapı 20 (YK20) is one of 37 shipwrecks discovered in Theodosius Harbor. YK20 is dated to AD 687-975 years by radiocarbon analyses. The preserved dimensions of the shipwreck, whose hull part is intact, are 8.76 m in length and 2.25 m in width. After *in situ* documentation, the hull was removed from the site; post-excavation documentation and construction technique studies were carried out at Istanbul University Yenikapı Shipwrecks Application and Research Center. According to archaeological evidence and preliminary reconstruction studies, YK20 is a small merchantman with a length of approximately 10.76 m, with Latin sails, built using the Mediterranean mixed construction method. It has similar construction characteristics to the Yenikapı shipwrecks YK9, YK12, and YK18, which have chestnut planks and planking edge dowel joints. In this article, the Yenikapı excavations, which lasted for nine years, and the history of the harbor are presented to create integrity with the subject, the documentation of the shipwreck is summarized, its general construction features and analysis are evaluated in comparison with the other Yenikapı shipwrecks.

Keywords
Boat and ship archaeology, Yenikapı shipwrecks, Theodosian Harbor, Byzantine shipbuilding

Öz

Marmaray ve Metro projeleri kapsamında, 2004-2013 yılları arasında İstanbul'un Yenikapı semtinde gerçekleştirilen kurtarma kazıları sırasında, Konstantinopolis'in önemli ticari ulaşım merkezi Theodosius Limanı ortaya çıkarılmıştır. Yenikapı 20 (YK20), Theodosius Limanı'nda keşfedilen 37 batıktan biridir. YK20, radyokarbon analizlerine göre 687-975 yılları arasına tarihlendirilmiştir. Karina kısmı sağlam olarak günümüze ulaşan batığın korunan boyutları 8,76 m uzunluk ve 2,25 m genişliktedir. Batık gövdesi, *in situ* belgelemesi yapıldıktan sonra araziden kaldırılmış; kazı sonrası belgeleme ve yapım tekniği çalışmaları İstanbul Üniversitesi Yenikapı Batıkları Uygulama ve Araştırma Merkezi'nde gerçekleştirilmiştir. Arkeolojik kanıtlar ve ön rekonstrüksiyon çalışmalarına göre YK20, Akdeniz karma yapım yöntemi ile inşa edilmiş, Latin yelkenli, yaklaşık 10,76 m uzunluğunda küçük bir ticaret gemisidir. Kestane kaplamalı ve kenar kavelalı olan Yenikapı batıklarından YK9, YK12 ve YK18 ile benzer konstrüksiyon özelliklerine sahiptir. Bu çalışmada,

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dokuz yıl süren Yenikapı kazıları ve limanın tarihçesi konu ile bütünlük oluşturmak amacıyla sunulmuş, batığın dokümantasyonu özetlenmiş, genel konstrüksiyon özellikleri ve analizi Yenikapı batıkları ile karşılaştırmalı olarak değerlendirilmiştir.

Anahtar Kelimeler
Gemi ve tekne arkeolojisi, Yenikapı batıkları, Theodosius Limanı, Bizans gemi inşası

Genişletilmiş Özet

Yenikapı kurtarma kazıları, İstanbul Arkeoloji Müzeleri başkanlığında, 2004-2013 yılları arasında sürdürülmüştür. Derinliği 12 m olan dolguda gerçekleştirilen kazılar sırasında, Neolitik dönemden son Osmanlı dönemine kadar aralıksız bir tabakalanma tespit edilmiş; İstanbul'un kültür tarihini zenginleştiren yüz binlerce eser ve mimari kalıntı ortaya çıkarılmıştır. Theodosius Limanı'nın ve 600 yıllık süreçte farklı zamanlarda batmış olan 37 gemi kalıntısının keşfi ise denizcilik tarihi ve gemi yapım teknolojisi hakkında eşsiz bilgiler sunmaktadır. Yenikapı batıkları kullanımlarına göre ticaret gemileri ve kadırgalar olarak iki grupta ele alınmaktadır. 5.-11. yüzyıllar arasına tarihlenen ticaret gemileri, yaklaşık 7 m uzunluğundaki küçük teknelerden 40 m'ye ulaşan açık deniz gemilerine kadar çeşitli boyut ve özelliktedir. Kürekli küçük savaş gemileri olan Yenikapı kadırgalarının tahmini orijinal uzunlukları ise yaklaşık 30 m'dir. Bu kadırgalar, Bizans dönemine tarihlenen arkeolojik örneklerinin ilk kez Yenikapı'da ele geçmiş olması sebebiyle ayrı bir değer taşımaktadır.

2008 yılında kazı alanının doğu tarafında keşfedilen YK20 batığı, gövde bütünlüğünü koruyarak günümüze ulaşmış ticaret teknelerinden biridir. Batık, bir tarafının ikinci çapa tahtasına kadar korunmuş olması; yelken yatağı, iç kuşakları, kemere parçası gibi kazılarda nadir ele geçen ahşap elemanlarının in situ olarak ele geçmesi gibi sebeplerle gemi inşa teknolojisi çalışmaları açısından önemli verilere sahiptir. Batığın arazideki in situ belgelemesi Total Station® cihazıyla 3 boyutlu olarak gerçekleştirilmiştir. Ayrıca, kaplama yüzeyleri asetat kâğıdına 1:1 ölçeğinde çizilmiş; fotoğraflanmış ve foto-mozaikleri oluşturulmuştur. Belgeleme sonrasında batık gövdesi sökülmüş, "L" profiller ve destekler yardımıyla ahşaplar kaldırılmış ve İstanbul Üniversitesi Yenikapı Batıkları Uygulama ve Araştırma Laboratuvarı'ndaki havuzlara taşınmıştır. Laboratuvarda, YK20 batığının her bir ahşap elamanı, 3 boyutlu temaslı ölçüm cihazı ile tam ölçekli olarak çizilmiş ve ayrıntılı olarak fotoğraflanmıştır. Ahşap elemanlar üzerinde yapılan detaylı analizler sonucunda, geminin yapım teknolojisi, inşasında kullanılan aletler, ustanın işaretleri ve konstrüksiyon özellikleri hakkında detaylı bilgilere ulaşılmıştır. Dokümantasyon ve teknoloji çalışmaları tamamlandıktan sonra, batık ahşapları üzerinde bozulma durumuna yönelik analizler gerçekleştirilmiştir. PEG (polietilen glikol) emdirmesi ve dondurarak kurutma olarak karar verilen konservasyon süreci İÜ Yenikapı Batıkları Projesi Uygulama ve Araştırma Laboratuvarı'nda devam etmektedir.

Akdeniz gemi inşası, kabuk-ilk ve iskelet-ilk olarak tanımlanan başlıca iki yöntem ve bu yöntemlerin gelişimi üzerinden ele alınmaktadır. Kabuk-ilk yöntemi önce omurga ve iki yanına yerleştirilen kaplama tahtalarının inşası ile başlamaktadır. Bu inşanın temel özelliği geminin tasarım ve şeklinin kaplamalar tarafından belirlenmesidir. Döşek ve postalar kaplamalardan oluşan kabuk tamamlandıktan sonra inşaya eklenmektedir. Günümüzde de uygulanan iskelet-ilk tekniğinde ise bunun tam tersi bir metodoloji bulunmaktadır. Birbirine bağlanmış döşek ve postalardan oluşan iskelet omurgaya sabitlendikten sonra kaplamalar bunların üzerine monte edilmektedir. Bu yöntemde gövdenin tasarım ve dayanımı iskelet sistemi tarafından sağlanmaktadır. Gemi inşa tarihinde iki uçta bulunan bu tekniklerin arasında bulunan geçiş dönemi uzun bir sürece yayılmıştır. Bu dönemde gerçekleştirilen yapım yöntemi "karma inşa" olarak isimlendirilmektedir. Gemi arkeolojisinden gelen kanıtlar, MS 2. yüzyıl ortasından sonra gevşeyen ve aralıkları artan zıvanalı geçmelerle başladığı öne sürülen teknolojideki değişim sürecinin 13. yüzyıla kadar devam ettiğini göstermektedir. Yenikapı batıkları bu uzun geçiş dönemindeki karma inşa sürecinin 5.-11. yüzyıllar arasındaki gelişimini örnekleyerek gemi inşa teknolojisinde dikkate değer bir boşluğu doldurmuştur. Bu batıklardan biri olan YK20 karma inşanın özelliklerini taşıyan bir gövdeye sahiptir. Alt gövdesinde, kaplama tahtaları omurgadan birinci çapa tahtasına kadar kenar kavelaları ile birbirine düzenli aralıklar ile bağlanmıştır. Bu kenar kavelaları gövde içindeki eğrilerin alt hizalarına denk gelmektedir. Uzun kaplama tahtaları boyuna birleşimlerinde ise S-biçimli parileler ile birbirine eklenmiştir. Bu yapım özellikleri, teknenin alt gövdesinin kabuk-temelli felsefeye göre inşa edildiğinin kanıtlarıdır. Bununla birlikte, birinci çapa tahtasından sonra boyuna elemanlar arasında kenar birleştirmeleri tespit edilmemiştir. İnşanın bu aşamasından sonra gövdenin şekillendirilmesinde ağırlıklı olarak eğriler rol almıştır. Diğer çoğu Yenikapı batığında ve bu yöntemle inşa edilen Akdeniz gemilerinde rastlanan bu durum karma inşanın en karakteristik özelliklerinden biridir. Teknenin inşasında altı farklı ağaç cinsi tespit edilmiştir. Kaplamalarda Anadolu kestanesi, döşek ve postalar meşe, omurga elemanları ve yelken yatağında ise kayın ağaçları kullanılmıştır. Sayıca az olan karaağaç, karaçam ve çınar ağaçlarının ise inşadan farklı zamanlarda gerçekleştirilen onarımlarda gövdeye eklendiği belirlenmiştir. Elemanların şekillendirileceği ağaç türlerinin, gövdedeki kullanım yerlerinin özelliklerine göre seçilmesi, Yenikapı batıklarında tespit edilen karakteristik inşa özelliklerindendir. Meşe, Anadolu Kestanesi ve Kayın ağaçlarının doğal yayılım alanlarının Karadeniz ve Marmara çevresinde olması, inşada kullanılan ağaçların Anadolu'nun kuzey coğrafyasından sağlandığına işaret etmektedir. YK20 ahşaplarının Oxford Üniversitesinin Radyokarbon Hızlandırma Ünitesi'nde gerçekleştirilen radyokarbon analizleri, MS 687-975 yılları arasını göstermektedir. Batık bu analizler ve bulunduğu tabaka doğrultusunda 9.-10. yüzyıllara tarihlendirilmektedir.

Ön rekonstrüksiyon çalışmalarına göre YK20, yaklaşık 10,76 m uzunluğunda ve 2,66 m genişliğinde küçük bir ticaret teknesidir. Tek direkli, büyük olasılıkla Akdeniz'deki Bizans gemilerinde yaygın olduğu gibi, Latin/Settee yelken donanımı ile sevk ettirilmekte ve döneminin karakteristiği olan bir çift çeyrek dümenle kontrol edilmektedir. Kıç tarafında kapaklı bir depolama bölmesine sahiptir. Orta kısmında gövde altı açısı olabildiğince düşük ve düz diplidir.

Introduction

Established in the 7th century BC and controlling the connection between the Black Sea and the Mediterranean with its location at the mouth of the Bosporus, Byzantium has been an important commercial center for centuries with its strategic location.[1] The city, which started to be called Constantinople after the capital of the empire was moved here by Constantine I in 330 AD, was divided into 14 administrative regions, just like Rome.[2] In addition, it has been made attractive in various ways, and its population has started to increase rapidly. It is said that the construction of a new and larger port called *Portus Iulianos* (Harbor of Sophia) was begun in a bay on the south coast of the city facing the Marmara Sea during the reign of emperor Iulianos (r. AD 361-363), as the capacity of the old ports began to fall short in the face of the rapid population growth in the newly established city.[3] Another port referred to as *Portus Theodosiacus* (Theodosian Harbor)[4] in the *Notitia* of Constantinople, written in the 5th century, was probably founded by Theodosius I (r. AD 379-395) in a deep and wide bay in Region XII.[5] Granaries called *Horrea Alexandrina* and *Horrea Theodosiana*, named after Alexandria, Egypt, and the emperor himself, respectively, were located on the Theodosian Harbor's east side, which was within Region IX; thus, these suggest that this harbor was used for loading the grains brought from Egypt and the other items and this was a large commercial harbor.[6] Although there are different opinions about the name and establishment of the port, the *Eleutherios* Harbor, which is mentioned in the sources as being in the same region, is probably the predecessor of the Theodosian Harbor (**F.1**). With the Arab conquests in the Mediterranean region in the 7th century, the Mediterranean Sea, which was a Byzantine lake until then, the grain shipments imported from Egypt stopped, and the port of Theodosius naturally lost one of its most essential functions. Theodosian Harbor lost its primary function when the grains transportation from Egypt ended toward the middle of the seventh century; however, it continued to serve as a harbor, as attested from the shipwrecks uncovered dating from the seventh through the eleventh centuries.[7]

1 Petrus Gyllius, *İstanbul'un Tarihi Eserleri*, trans. Erendiz Özbay (İstanbul: Eren Yayıncılık, 1997), 29-31; Rahmi Asal, "Yenikapi Excavations and Trade in Istanbul in Antiquity*," Stories from the Hidden Harbor: The Shipwrecks of Yenikapı,* eds. Zeynep Kızıltan and Gülbahar Baran-Çelik (Istanbul: İstanbul Arkeoloji Müzeleri, 2013), 7.

2 Oğuz Tekin, *Eski Yunan ve Roma Tarihine Giriş* (İstanbul: İletişim Yayıncılık, 2008), 297.

3 Wolfgang Müller-Wiener, *Bizans'tan Osmanlı'ya İstanbul Limanları*, trans. Erol Özbek (İstanbul: Tarih Vakfı, 1998), 8.

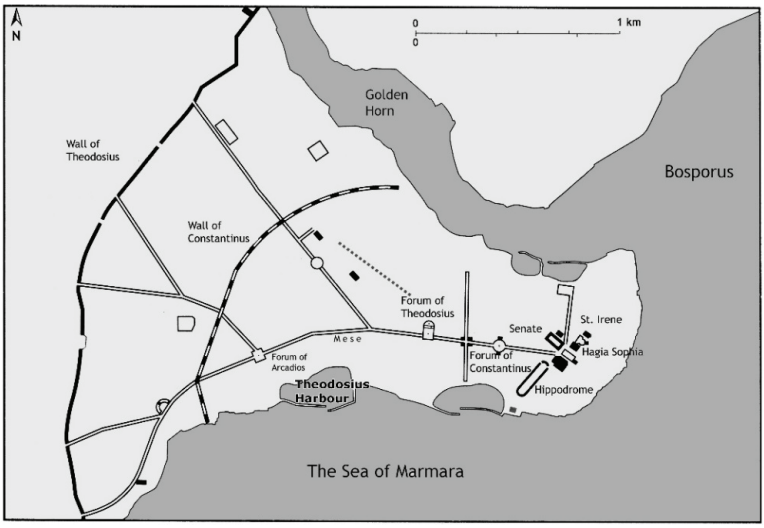
4 Paul Magdalino, "The Harbors of Byzantine Constantinople," *Stories from the Hidden Harbor: The Shipwrecks of Yenikapı,* eds. Zeynep Kızıltan and Gülbahar Baran-Çelik (Istanbul: İstanbul Arkeoloji Müzeleri, 2013), 14.

5 Müller-Wiener, *Bizans'tan Osmanlı'ya İstanbul Limanları*, 8.

6 Cyril Mango, "The Development of Constantinople as an Urban Centre," *The 17th International Byzantine Congress, Major Papers*. New York: Caratzas, 1986, 121.

7 Asal, "Yenikapi Excavations and Trade in Istanbul in Antiquity," 9.

Yenikapı excavations were carried out between 2004 and 2013 under the direction of the Istanbul Archaeological Museums. In the excavations realized in the 12 m deep fill, a continuous stratification was found from the Neolithic period to the last Ottoman period; hundreds of thousands of artifacts and architectural remains that enrich the cultural history of Istanbul have been unearthed.[8] The remains of 37 ships sunk at different times in 600 years provided unique information about maritime history and shipbuilding technology.[9]



F. 1: Map of Constantinople and Theodosian Harbor
(Haldon, John, *Bizans Tarih Atlası*, 72)

1. Yenikapı Shipwrecks and Shipbuilding Techniques in the Mediterranean

The Yenikapı shipwrecks are dated to the 5th to 11th centuries as the world's most extensive collection of medieval ships. Offering unique data on the typology of Byzantine ships and the evolution of their construction techniques, these shipwrecks are considered a part of the most significant project of recent times for scientists specialized in maritime archaeology. 27 of these 37 shipwrecks are currently under study by experts from the Department of Conservation of Marine Archaeological Objects,

8 Zeynep Kızıltan, "Excavations at Yenikapı, Sirkeci and Üsküdar within Marmaray and Metro Projects," *Archaeological Museums, Proceedings of the 1st Symposium on Marmaray-Metro Salvage Excavations 5th–6th May 2008, Istanbul,* ed. Ufuk Kocabaş (Istanbul: İstanbul Arkeoloji Müzeleri, 2010), 1-16; Mehmet Ali Polat, "Neolithic Period," *Stories from the Hidden Harbor: The Shipwrecks of Yenikapı*, eds. Zeynep Kızıltan and Gülbahar Baran Çelik (Istanbul: İstanbul Arkeoloji Müzeleri, 2013), 75-93; *Stories from the Hidden Harbor: The Shipwrecks of Yenikapı,* eds. Zeynep Kızıltan and Gülbahar Baran Çelik (Istanbul: İstanbul Arkeoloji Müzeleri, 2013); Ufuk Kocabaş, *Geçmişe Açılan Kapı: Yenikapı Batıkları* (İstanbul: Ege Press, 2015), 37-45. Cemal Pulak, Rebecca Ingram and Michael Jones, "Eight Byzantine Shipwrecks from the Theodosian Harbour Excavations at Yenikapı in Istanbul, Turkey: An Introduction," *International Journal of Nautical Archaeology* 44.1 (2015), 39-73.

9 Işıl Özsait-Kocabaş, "Bir Bizans Teknesinin Anatomisi: Yenikapı 8 Batığı." *Art-Sanat* 11 (Ocak 2019), 326, accessed January 16, 2019, https://doi.org/10.26650/artsanat.2019.11.0015.

Istanbul University. The most significant feature of Yenikapı shipwrecks is that they survived to the present day in a well-preserved state. Forms and *in situ* conditions of the timbers of the shipwrecks are entirely recognizable. Thus, the original shapes of the hulls and the curves of their framing systems are clearly visible.[10]

As demonstrated by the Yenikapı shipwrecks, the Early Medieval Period witnessed a transition from the shell-first to the skeleton-first technique, constituting a link between Antiquity and Modernity in shipbuilding. Mediterranean shipbuilding is discussed through the two main methods defined as shell-first and skeleton-first, and the development of these methods. The shell-first process begins with placing the keel and the planks on both sides. The main feature of this construction is that the planking determines the design and shape of the ship. Floor timbers and futtocks are added to the construction after the outer shell consisting of coverings is completed. The skeleton-first technique, which is still applied today, has the opposite methodology. The skeleton, which consists of floor timber and futtock connected to each other, is fixed to the spine. Planks are coated over the framing system. In this method, the design and strength are provided by the frames. The transition period between these two main techniques in the history of shipbuilding has spread over a long period. The construction method in this period is called mixed construction. Evidence from boat and ship archeology shows that the change in technology, which is claimed to have started with mortise-and-tenon joints that loosened and increased in intervals after the middle of the 2nd century AD, continued into the 13th century.[11] Yenikapı shipwrecks represented the progress in the 5th-11th phases of the mixed construction process in this extended transition period and filled a significant gap in shipbuilding technology.[12]

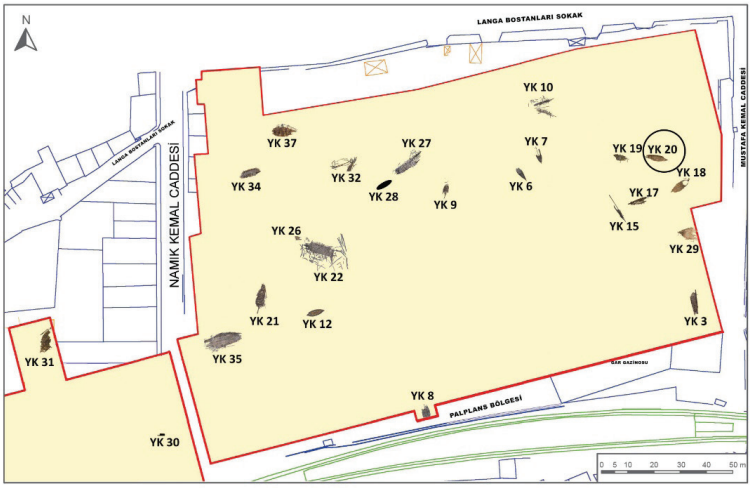
The Yenikapı shipwrecks are categorized into two main groups: galleys and merchantmen. Yenikapı merchantmen or trade ships are divided into three groups according to their edge-joined planking. Those with a mortise-and-tenon joint, an edge dowel joint, and those without any edge joint. Other methods that can be used to categorize these ships are

10 Ufuk Kocabaş, "The Latest Link in the Long Tradition of Maritime Archaeology in Turkey: The Yenikapı Shipwrecks," *European Journal of Archaeology* 15.1 (2012), 6-12.

11 *Excavations Arquològiques Subaquàtiques a Cala Culip, 2. Culip VI. Monografies del CASC, Vol. 1*, eds. Xavier Nieto ve Xim Raurich (Girona: Museu d'Arqueologia de Catalunya, 1998); Patrice Pomey, Yaacov Kahanov and Eric Rieth, "Transition from Shell to Skeleton in Ancient Mediterranean Ship-Construction: Analysis, Problems, and Future Research," *International Journal of Nautical Archaeology* 41.2 (2012), 297; Işıl Özsait-Kocabaş, *Yenikapı 12-An Early Medieval Merchantmean/Yenikapı12-Erken Orta Çağ Ticaret Teknesi* (İstanbul: Ege Press, 2022), 292-299.

12 Frederick H. van Doorninck Jr., "The Hull Remains," *Yassı Ada, Vol. I: A Seventh-Century Byzantine Shipwreck,* eds. George F. Bass and Frederick H. van Doorninck Jr. (College Station, TX: Texas A&M University Press, 1982), 84; Ufuk Kocabaş, "The Yenikapı Byzantine-Era Shipwrecks, Istanbul, Turkey: A Preliminary Report and Inventory of the 27 Wrecks Studied by Istanbul University," *International Journal of Nautical Archaeology* 44.1 (2015), 5-38; Kocabaş, "The Yenikapı Byzantine-Era Shipwrecks, Istanbul, Turkey: A Preliminary Report and Inventory of the 27 Wrecks Studied by Istanbul University"; Pulak, Ingram and Jones, "Eight Byzantine shipwrecks from the Theodosian Harbour excavations at Yenikapı in Istanbul, Turkey: An Introduction"; Rebecca Ingram, "The Hull of Yenikapı Shipwreck YK 11: A 7th-century Merchant vessel from Constantinople's Theodosian Harbour*," International Journal of Nautical Archaeology* 47.1 (2018), 114.

classifications made according to their size (small, medium, large) or the ship geometry (flat-floored or wineglass-shaped). It is determined that most shipwrecks without edge-joined have rabbeted keels, and their planks are joined with diagonal, butt, and three-planed scarfs. Shipwrecks belonging to this group are dated between the 7th and 9th centuries.[13] Among the Yenikapı shipwrecks, the earliest dated shipwrecks are mortise-and-tenon jointed shipwrecks, and only one of them, YK34, has pegged mortise-and-tenon joints. One of the essential features of these shipwrecks is that their cross-sections are in the form of wineglass-shaped. They have thick planking and diagonal and "S" shaped scarfs. Shipwrecks belonging to this group are dated between the 5th and 7th centuries.[14] In the shipwrecks, the third and the largest group of Yenikapı shipwrecks, planking edge dowels were used from the bottom to the waterline. The planking of these shipwrecks (which generally have a flat-bottomed cross-section in their amidships cross-sections) is combined with diagonal and "S" scarfs longitudinally. The transverse holes drilled in the keel timbers are most likely the rope hole used to haul the ship ashore. Shipwrecks belonging to this group are dated between the 7th and 10th centuries.[15]



F. 2: Yenikapı Site and location of shipwreck YK20
(IU Yenikapı Shipwrecks Project Archive, 2015)

13 Evren Türkmenoğlu, "Preliminary Report on the Yenikapı 17 Shipwreck," *Between Continents: Proceedings of the Twelfth Symposium on Boat and Ship Archaeology, Istanbul 2009,* ed. Nergis Günsenin (Istanbul: Ege Press, 2012), 121-125; Işıl Özsait-Kocabaş, "The Yenikapı 12 Shipwreck, a 9th-Century Merchantman from the Theodosian Harbour in Istanbul, Turkey: Construction and Reconstruction," *International Journal of Nautical Archaeology* 47.2 (2018), 380-381.

14 Kocabaş, "The Yenikapı Byzantine-Era Shipwrecks, Istanbul, Turkey: A Preliminary Report and Inventory of the 27 Wrecks Studied by Istanbul University," 30; Özsait-Kocabaş, "The Yenikapı 12 Shipwreck, a 9th-Century Merchantman from the Theodosian Harbour in Istanbul, Turkey: Construction and Reconstruction," 381.

15 Özsait-Kocabaş, *Yenikapı 12-An Early Medieval Merchantmean/Yenikapı12-Erken Orta Çağ Ticaret Teknesi*, 279.

2. Studies on the Shipwreck Yenikapı 20

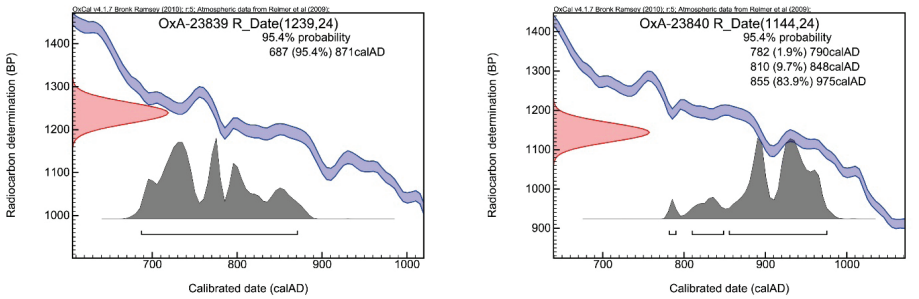
Shipwreck YK20 was discovered at a level of 0.70 - 1.00 m on the east side of the excavation site (**F.2**). Field works on YK 20 began in 2008 by setting up a protective tent and an atomizing watering system over the shipwreck. Once the shipwreck was carefully uncovered, its timbers were cleaned, labeled, and documented (**F.3**). During the *in situ* documentation process, the vessel was mapped using Total Station®. Then it was created as the photo-mosaics that combines the vessel's photos on a frame-by-frame basis (**F.4**).

F. 3: Fieldwork on YK20 (IU Yenikapı Shipwrecks Project Archive, 2008)

F. 4: Measurements using Total Station® (IU Yenikapı Shipwrecks Project Archive, 2008)

Upon completing the entire field work, all parts of the shipwreck were dismantled and placed in wooden crates, which were then transported to the preservation pools in Yenikapı Shipwrecks Project Application and Research Laboratory of the Istanbul University, located near the excavation site.[16] At the laboratory, each part of shipwreck YK 20 is drawn on a full-scale and photographed in detail to reveal the vessel's technical specifications 1:1 scale drawings are made using a digitizer called FaroArm®, which can create 3D drawings with high accuracy. Detailed analyses of the ship's timbers provided a great deal of information, such as the tools used in shipbuilding, markings of the shipwright, and the specific tree parts from which the wooden components were manufactured.[17] These drawings will be used in the reconstruction of shipwreck YK 20 in further stages. The documentation and technology studies of YK20 timbers have been completed, and the polyethylene glycol (PEG) impregnation stage of conservation has been started at the IU Yenikapı Shipwrecks Project Application and Research Laboratory.[18]

As in all archaeological studies, dating shipwrecks is also significant for working out a chronology and identifying the periods of use for the vessels. Wood samples collected to this end were sent to Oxford Radiocarbon Accelerator Unit (ORAU) for age determination analysis. The shipwreck YK20 is dated 687–975 by radiocarbon analyses (**F.5**).



F. 5: Radiocarbon analysis results for shipwreck YK20. All samples analyzed by Oxford Radiocarbon Accelerator Unit, calibrated using OxCal V4 1.7

16 Ufuk Kocabaş, Işıl Özsait-Kocabaş and Namık Kılıç, "The Yenikapı Shipwrecks: Dismantling Methods and First Step to Conservation," *11th ICOM International Conference on Wet Organic Archaeological Materials (ICOM-WOAM), Greenville, 2010*, eds. Kristiane Straetkvern and Emily Williams (USA: ICOM Committee for Conservation, 2012), 303-312.

17 Taner Güler, "Construction Technique of the Yenikapı 20 Shipwreck, Found in the Harbour of Theodosius (Istanbul, Turkey)," *Ships and Maritime Landscapes: Proceeding of the Thirteenth International Symposium on Boat and Ship Archaeology, Amsterdam 2012*, eds. Jerzy Gawronski, André van Holk and Joost Schokkenbroek. (Amsterdam: Barkhuis, 2017); Taner Güler, "Yenikapı 20 Batığının Konstrüksiyon Özellikleri ve Yapım Tekniği Önerisi," (PhD diss., Istanbul University, 2019).

18 Ufuk Kocabaş, Namık Kılıç and Rahmi Asal, "Keeping The Past Alive: The Yenikapı Shipwrecks," *TINA Maritime Archaeology Periodical* 14, eds. Mehmet Bezdan and Ufuk Kocabaş (Istanbul: Bilnet Matbaacılık ve Yayıncılık, 2020); Namık Kılıç and Gökçe Kılıç, "Analysis of Waterlogged Woods: Example of Yenikapı Shipwrecks," *Art-Sanat* 9 (Aralık 2018), 1-11, accessed September 10, 2022, https://dergipark.org.tr/tr/download/issue-full-file/47878.

(Kocabaş, "The Yenikapı Byzantine-Era Shipwrecks, Istanbul, Turkey: A Preliminary Report and Inventory of the 27 Wrecks Studied by Istanbul University," 17)

3. Construction Characteristics of Yenikapı 20

Shipwreck YK20 has a length of 8.76 m and a width of 2.25 m. The surviving parts of the vessel include 28 frame stations (floor timbers and futtocks), the keel timbers, the mast-step timber, two wale, twenty planking strakes, two stringers, and a beam fragment. The hull's starboard side remained intact up to the second wale, and its bottom was well preserved (**F.6**).

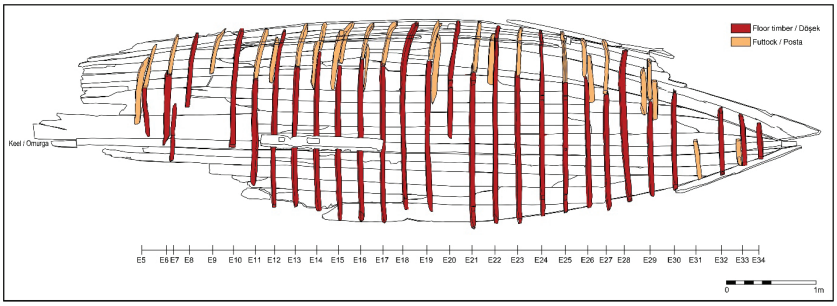
F. 6: Photo-mosaic of YK20 (IU Yenikapı Shipwrecks Project Archive, 2008)

The 8.50 m long keel remnant consists of a central and curved keel timber. The central keel timber without rabbets was formed beech. Curved keel timber was joined to the aft side of keel timber by a hook scarf and had a transverse hole (**F. 7**). Similar transverse holes have also been identified in some Yenikapı shipwrecks.[19] Fourteen planking strakes on the starboard side and six on the port side of the YK20 hull have survived. S-shaped scarfs were used in the longitudinal joining of planks. The planks were fastened together with regularly spaced dowels (coaks), and luting was laid between the plank seams. A wale was detected between the thirteenth and fourteenth planking strakes and ones above the fourteenth strake on the starboard side of YK20. The wales have a curved outer surface and the flat inner surface.

F. 7: Transverse hole on the curved keel timber (left),
(IU Yenikapı Shipwrecks Project Archive, 2008)
F. 8: L-shaped scarf end of the floor timber (right),
(IU Yenikapı Shipwrecks Project Archive, 2008)

19 Kocabaş, "The Yenikapı Byzantine-Era Shipwrecks, Istanbul, Turkey: A Preliminary Report and Inventory of the 27 Wrecks Studied by Istanbul University," 15, 20; Pulak, Ingram and Jones "Eight Byzantine shipwrecks from the Theodosian Harbour excavations at Yenikapı in Istanbul, Turkey: An Introduction," 52.

In the shipwreck YK20, 28-floor timbers and 27 futtocks survived. The framing system consisted of floor timbers, futtocks that continue in line with the floor timbers, and side futtocks. Futtocks that continue at the same line were placed on the "L" shaped ends of the floor timbers (**F. 8**). Side futtocks were located on the fore and aft sides of the floor timbers. In the framing pattern, long-armed floor timbers were placed alternately on the starboard and port sides (**F. 9**). The floor timbers have rounded limber-holes, one on each side of the keel. The frames were made predominantly of oak. The frames were attached to the planks with treenails and iron nails and were joined to the keel timbers with iron nails.



F. 9: Framing pattern of YK20 (IU Yenikapı Shipwrecks Project Archive, 2010)

It was determined that a compartment might have been used for the crew's personal belongings towards the stern of the vessel. The main evidence of this compartment is the bulkhead futtock E25-S1 and the beam fragment next to it. The mast-step timber, whose length is 137 cm, was located between floor timbers Fr11 and Fr17. beam fragments or their locations were also found in the YK5, YK11, YK12, and YK14 shipwrecks in the excavation site.[20] The mast-step timber was placed slightly forward of amidships on the floor timbers thanks to the notches opened on the lower surface (**F. 10**). It also has two mortises on its upper surface. The larger mortise must have been cut to accommodate the ship's mast, while the small one seems to have served as mast support. The mast-step timber of the YK12, like the YK 20, was placed on the floor timbers with notches cut under it.[21] Chestnut stringers were attached to the inner surface of the frames at the same line along the hull.

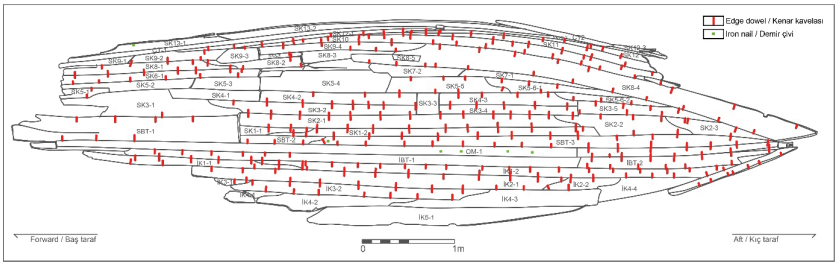
20 Ingram, "The Hull of Yenikapı Shipwreck YK 11: A 7th-century Merchant vessel from Constantinople's Theodosian Harbour," 129; Özsait-Kocabaş "The Yenikapı 12 Shipwreck, a 9th-Century Merchantman from the Theodosian Harbour in Istanbul, Turkey: Construction and Reconstruction," 369; Pulak, Ingram and Jones, "Eight Byzantine Shipwrecks from the Theodosian Harbour Excavations at Yenikapı in Istanbul, Turkey: An Introduction," 54, 57.

21 Özsait-Kocabaş, "The Yenikapı 12 Shipwreck, a 9th-Century Merchantman from the Theodosian Harbour in Istanbul, Turkey: Construction and Reconstruction," 367-368.

F. 10: The mast-step timber and stringer on the hull
(IU Yenikapı Shipwrecks Project Archive, 2008)

YK 20 is an example of a construction technique referred to as the Mixed Construction Technique, representing the transition from shell-first to skeleton process as the two main Mediterranean shipbuilding methods. The hull planking was homogenously edge-joined with dowels to the first wale (**F.11**). The lower hull of the YK20 reflects the shell-based construction philosophy with its long planks, S-shaped scarfs, and frame stations overlapping the plank-edge dowels. However, the strakes above the first wale lacked edge fasteners. This construction technique, also seen in other Yenikapı shipwrecks, is one of the most characteristic features of mixed construction. Probably, after this construction stage, frames instead of planks played an active role in shaping the hull. The alternating framing pattern reflects the emphasis placed on the framing system. The stringers connected to the frames reinforce the integrity of the transverse elements and support the longitudinal strength of the hull. Reinforcing the framing among themselves is an essential criterion for hulls with mixed construction.[22]

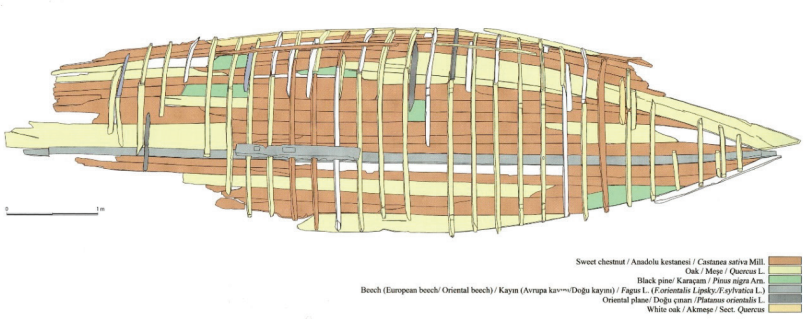
22 Pomey, Kahanov and Rieth, "Transition from Shell to Skeleton in Ancient Mediterranean Ship-Construction: Analysis, Problems, and Future Research," 236.



F. 11: Location of plank-edge dowels on planking plan
(IU Yenikapı Shipwrecks Project Archive, 2010)

4. Wood Analyses

Wood samples were taken from members of the hull to identify tree species, and these samples were studied by Prof. Ünal Akkemik (**F. 12**).[23] Accordingly, the analyses on the timbers of YK20 demonstrate that six different wood species were mainly used to build the ship. The selection of these woods with various properties for different parts of the vessel was based on their durability in different places of use. The planking was made of chestnut trees (*Castanea* L.). Beech (*Fagus* L.) was used for the keel and the mast-step, and oak (*Quercus* L.) was preferred for the frames. Black pine (*Pinus nigra* L.), oriental plane (*Platanus orientalis* L.), and elm trees (*Ulmus* L.) were mainly used for the repair parts. Oak trees grow in a broader habitat range, while sweet chestnut is native to the Black Sea region. Beech grows in the Black Sea, Marmara and Aegean regions, indicating that the timbers used on the ship were procured from the northern parts of Anatolia.



F. 12: Wood type/species identification of shipwreck YK20
(Akkemik, *Yenikapı Shipwrecks Volume II: Woods of Yenikapı Shipwrecks*, 77)

23 Ünal Akkemik, *Yenikapı Shipwrecks Volume II: Woods of Yenikapı Shipwrecks* (Istanbul: Ege Press, 2015), 197-199; Ünal Akkemik ve Ufuk Kocabaş, "Woods of Byzantine Trade Ships of Yenikapı (Istanbul) and Changes in Wood Use from 6th to 11th Century," *Mediterranean Archaeology and Archaeometry* 14.2 (2014), 323.

5. Repairs

With plenty of repair parts, YK 20 is believed to have been used for a long time. The best evidence of repairs on the YK20 hull is the cut-edge dowels that do not continue on the side plank and the different wood types in these locations. The scarf shapes that do not fit the general layout of the hull are another essential criterion. Contrary to the central keel without rabbets and edge dowels, side dowels placed at regular intervals on the side edges of the keel side of the garboard have been identified. In addition, the scarf at the forward end of the central keel timber is in the form of a flat fitting, unlike the other end. The possibility of the central keel timber being replaced during a repair has been noted in previous publications.[24] Furthermore, some planks are flat-joint, unlike the common scarf form. The timbers with flat joints, whose edge dowels do not continue in the adjacent planks, are shaped from oak. In addition, the wooden patches, inconsistent with the planking pattern, are also made of oak and black pine. Finally, it is predicted that a few frames made of plane and elm trees were also added to the hull for repair and support after the construction of the vessel.

Conclusion

According to the preliminary reconstruction studies, the YK20 is a small merchantman, approximately 10.76 m in length and 2.66 m in width. YK20 was likely propelled by a Lateen or settee sail rig and steered with a pair of quarter rudders, as was standard at the Byzantine ships in the Mediterranean.[25] It has a covered storage compartment at the stern. Among the Yenikapı shipwrecks, they have similarities with the shipwrecks YK9, YK12, and YK18, which have chestnut planks with edge dowels joined in terms of construction characteristics.

The ship and boats in Yenikapı reveal the different stages of technological change between the 5th and 11th centuries. The construction of the shipwreck YK20 reflects the way mixed construction was practiced at the beginning of the 10th century. Today, the emergence of shell-first and skeleton-first construction techniques is still a highly controversial issue. Some researchers argue that shifting from shell-first to skeleton-first technique took time, a transition that constitutes an entirely different technique. YK 20 occupies an important place in maritime archaeology as a vessel built using a mixed construction technique. Ongoing analyses on the shipwreck are hoped to pave the way for future research.

24 Özsait-Kocabaş, "The Yenikapı 12 Shipwreck, a 9th-Century Merchantman from the Theodosian Harbour in Istanbul, Turkey: construction and reconstruction," 381.

25 Despoina Evgenidou, "Byzantine Shipbuilding," *Journeys on the Seas of Byzantium*, ed. Diana Zafiropoulou (Athens: Hellenic Ministry of Culture, 1997), 38; John H. Pryor, *Akdeniz'de Coğrafya, Teknoloji ve Savaş, Araplar, Bizanslılar, Batılılar ve Türkler,* trans. Füsun Tayanç and Tunç Tayanç (İstanbul: Kitap Yayınevi, 2004), 43.

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References/Kaynakça

Akkemik, Ünal. *Yenikapı Shipwrecks Volume II: Woods of Yenikapı Shipwrecks.* Istanbul: Ege Press, 2015.

Akkemik, Ünal and Ufuk Kocabaş. "Woods of Byzantine Trade Ships of Yenikapı (İstanbul) and Changes in Wood Use from 6th to 11th Century." *Mediterranean Archaeology and Archaeometry* 14.2 (2014): 317–327.

Asal, Rahmi. "Yenikapi Excavations and Trade in Istanbul in Antiquity." *Stories from the Hidden Harbor: The Shipwrecks of Yenikapı.* Edited by Zeynep Kızıltan and Gülbahar Baran Çelik. Istanbul: İstanbul Arkeoloji Müzeleri, 2013, 5–10.

Evgenidou, Despoina. "Byzantine Shipbuilding." *Journeys on the Seas of Byzantium.* Edited by Diana Zafiropoulou. Athens: Hellenic Ministry of Culture, 1997, 32–39.

Excavations Arquològiques Subaquàtiques a Cala Culip, 2. Culip VI. Monografies del CASC, Vol. 1. Edited by Xavier Nieto and Xim Raurich. Girona: Museu d'Arqueologia de Catalunya, 1998.

Güler, Taner. "Construction Technique of the Yenikapı 20 Shipwreck, Found in the Harbour of Theodosius (Istanbul, Turkey)." *Ships and Maritime Landscapes: Proceeding of the Thirteenth International Symposium on Boat and Ship Archaeology, Amsterdam 2012.* Edited by Jerzy Gawronski, André van Holk and Joost Schokkenbroek. Amsterdam: Barkhuis, 2017, 280-282.

Güler, Taner. "Yenikapı 20 Batığının Konstrüksiyon Özellikleri ve Yapım Tekniği Önerisi." PhD diss., Istanbul University, 2019.

Gyllius, Petrus. *İstanbul'un Tarihi Eserleri.* Translated by Erendiz Özbay. İstanbul: Eren Yayıncılık, 1997.

Haldon, John. *Bizans Tarih Atlası*. Trans. Ali Özdamar. İstanbul: Kitap Yayınevi, 2007.

Ingram, Rebecca. "The Hull of Yenikapı Shipwreck YK 11: a 7th-century Merchant Vessel from Constantinople's Theodosian Harbour." *International Journal of Nautical Archaeology* 47.1 (2018): 103-139. Accessed October 24, 2022. https://www.tandfonline.com/doi/full/10.1111/1095-9270.12293

Kılıç, Namık and Gökçe Kılıç. "Analysis of Waterlogged Woods: Example of Yenikapı Shipwrecks." Art-Sanat 9 (Aralık 2018), 1-11. Accessed September 10, 2022. https://dergipark.org.tr/tr/download/issue-full-file/47878.

Kızıltan, Zeynep. "Excavations at Yenikapı, Sirkeci and Üsküdar within Marmaray and Metro Projects." *Archaeological Museums, Proceedings of the 1st Symposium on Marmaray-Metro Salvage Excavations 5th–6th May 2008*, *İstanbul.* Edited by Ufuk Kocabaş. Istanbul: İstanbul Arkeoloji Müzeleri, 2010, 1-16.

Kocabaş, Ufuk. "The Latest Link in the Long Tradition of Maritime Archaeology in Turkey: The Yenikapı Shipwrecks." *European Journal of Archaeology* 15.1 (2012): 1–15. Accessed October 24, 2022. https://www.tandfonline.com/doi/full/10.1179/1461957112Y.0000000008

Kocabaş, Ufuk. "The Yenikapı Byzantine-Era Shipwrecks, Istanbul, Turkey: A Preliminary Report and Inventory of the 27 Wrecks Studied by Istanbul University." *International Journal of Nautical Archaeology* 44.1 (2015a): 5-38. Accessed August 16, 2022. https://doi.org/10.1111/1095-9270.12084

Kocabaş, Ufuk. *Geçmişe Açılan Kapı: Yenikapı Batıkları*. İstanbul: Ege Press, 2015.

Kocabaş, Ufuk, Namık Kılıç and Rahmi Asal. "Keeping the Past Alive: The Yenikapı Shipwrecks." *Maritime Archaeology Periodical* 14. Edited by Mehmet Bezdan and Ufuk Kocabaş. Istanbul: Bilnet Matbaacılık ve Yayıncılık, 2020, 14–55.

Kocabaş, Ufuk, Işıl Özsait-Kocabaş and Namık Kılıç. "The Yenikapı Shipwrecks: Dismantling Methods and First Step to Conservation." *11th ICOM International Conference on Wet Organic Archaeological Materials (ICOM-WOAM), Greenville, 2010*. Edited by Kristiane Straetkvern and Emily Williams. USA: ICOM Committee for Conservation, 2010, 303-312.

Magdalino, Paul. "The Harbors of Byzantine Constantinople." *Stories from the Hidden Harbor: The Shipwrecks of Yenikapı*. Edited by Zeynep Kızıltan and Gülbahar Baran-Çelik. İstanbul: İstanbul Arkeoloji Müzeleri, 2013, 11-15.

Mango, Cyril. "The Development of Constantinople as an Urban Centre." *The 17th International Byzantine Congress, Major Papers*. New York: Caratzas, 1986, 117-136.

Müller-Wiener, Wolfgang. *Bizans'tan Osmanlı'ya İstanbul Limanları*. Translated by Erol Özbek. İstanbul: Tarih Vakfı, 1998.

Özsait-Kocabaş, Işıl. "The Yenikapı 12 Shipwreck, a 9th-Century Merchantman from the Theodosian Harbour in Istanbul, Turkey: construction and reconstruction." *International Journal of Nautical Archaeology* 47.2 (2018): 357–390. Accessed August 16, 2022. https://www.tandfonline.com/doi/full/10.1111/1095-9270.12325

Özsait-Kocabaş, Işıl. "Bir Bizans Teknesinin Anatomisi: Yenikapı 8 Batığı." *Art-Sanat* 11 (Ocak 2019): 325–338. Accessed January 16, 2019. https://doi.org/10.26650/artsanat.2019.11.0015.

Özsait-Kocabaş, Işıl. *Yenikapı 12-An Early Medieval Merchantman/Yenikapı12-Erken Orta Çağ Ticaret Teknesi*. Istanbul: Ege Press, 2022.

Polat, Mehmet Ali. "Neolithic Period." *Stories from the Hidden Harbor: The Shipwrecks of Yenikapı*. Edited by Zeynep Kızıltan and Gülbahar Baran-Çelik. Istanbul: İstanbul Arkeoloji Müzeleri, 2013, 75-93.

Pomey, Patrice, Yaacov Kahanov and Eric Rieth. "Transition from Shell to Skeleton in Ancient Mediterranean Ship-Construction: Analysis, Problems, and Future Research." *International Journal of Nautical Archaeology* 41.2 (2012): 235-314. Accessed January 16, 2019. https://doi.org/10.1111/j.1095-9270.2012.00357.x

Pryor, John H. *Akdeniz'de Coğrafya, Teknoloji ve Savaş, Araplar, Bizanslılar, Batılılar ve Türkler*. Translated by Füsun Tayanç and Tunç Tayanç. İstanbul: Kitap Yayınevi, 2004.

Pulak, Cemal, Rebecca Ingram and Michael Jones. "Eight Byzantine Shipwrecks from the Theodosian Harbour excavations at Yenikapı in Istanbul, Turkey: An Introduction." *International*

Journal of Nautical Archaeology 44.1 (2015): 39–73. Accessed January 16, 2019. https://doi.org/10.1111/1095-9270.12083

Stories from the Hidden Harbor: The Shipwrecks of Yenikapı. Edited by Zeynep Kızıltan and Gülbahar Baran-Çelik. Istanbul: İstanbul Arkeoloji Müzeleri, 2013.

Tekin, Oğuz. *Eski Yunan ve Roma Tarihine Giriş*. İstanbul: İletişim Yayıncılık, 2008.

Türkmenoğlu, Evren. "Preliminary Report on the Yenikapı 17 Shipwreck." *Between Continents: Proceedings of the Twelfth Symposium on Boat and Ship Archaeology, Istanbul 2009.* Edited by Nergis Günsenin. Istanbul: Ege Press, 2012, 121-125.

van Doorninck, Frederick H., Jr. "The Hull Remains." *Yassı Ada, Vol. I: A Seventh-Century Byzantine Shipwreck*. Edited by George F. Bass and Frederick H. van Doorninck Jr. College Station, TX: Texas A&M University Press, 1982, 32–64.