

A Quantitative Look at Mediterranean Lateen- and Square-Rigged Ships (Part 1)

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Modern-day engineering can be a useful tool to help understand the technological changes which led to the development of the three-masted ships of the modern age of sail, in the beginning of the 15th century. Recent finding and excavation of an increasing number of medieval shipwrecks offers the opportunity, and the authors propose to build a database with technical characteristics of late-medieval vessels in the hope of finding patterns that will help understand the relatively-quick technological evolution of Mediterranean merchant craft of the 14th and 15th centuries.

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It is difficult to explain technological change in shipbuilding history. Any particular ship-design is the result of a number of human and natural factors. Ship-construction is governed by the shipbuilder's knowledge, skills, tradition, and taste as well as the materials, tools, and technology available (Englert, 2000: 3). The purpose for which a ship is built must also be considered, and its means of propulsion incorporated in the design. Often so many social, political, economical, technological, and even symbolic factors play important roles in stimulating these changes, that it is difficult to weigh their importance as determinants of a particular technological shift at any particular time.

Sometimes changes can be explained by the development or adoption of a new technology, but often the questions that arise are more complex. For instance, why were square sails replaced by

lateen sails in the Mediterranean during the first half of the 6th century, at least in some types of craft? What were the main advantages of this new type of rig in each particular instance? The answers may lie in the reduction of the size of the average merchantman, and on a desire to improve the vessel's speed, perhaps due to the depression in Western Europe that followed the barbarian invasions, which cause a sharp contraction in commerce and spread insecurity all over Europe. Jacques Le Goff wrote about the 6th century: 'In this impoverished, underfed, weakened world a natural calamity succeeded in completing what the barbarians had begun. From AD 543 bubonic plague from the east ravaged Italy, Spain, and a great part of Gaul for more than half a century' (2000: 32). Certain commerce routes endured through to the later middle ages, along both rivers and coasts. Since the Roman road system

was one of the first victims of the fall of the empire, the new invaders established themselves by choice in cities located along rivers and coasts (Le Goff, 2000: 25–9). Salt, wine, oil, and a number of fine stuffs and spices were still sought by these invaders, and had to be transported over water in smaller merchant vessels. The reduction of the size of merchantmen fits well with the change in their rigging: lateen sails are easy to handle if the vessels are small.

But the truth is that we don't know much about this process of change. Information about which ship-types first adopted lateen sails and which kept square sails is not available. It would be useful to know which routes were first ploughed by the vessels that adopted the new lateen rig, and why. Considering the natural desire for security of all merchants, one may be tempted to think that ships carrying expensive cargoes may have led this technological innovation, rather than those transporting, for instance, salt in bulk. It is not known which shipwrights implemented the required constructional changes, how long and expensive were the introductory periods and, perhaps more important, how did shipwrights acquire the know-how needed to implement these changes. Where did the knowledge necessary to implement the new rigging reside, and how was it transferred, are interesting questions. And how easy was it for captains and sailors to adapt to this new technology?

There are reasons to believe that both lateen and square rigs coexisted in the Mediterranean throughout the Middle Ages. It is unlikely that square sails—although almost completely absent from Mediterranean iconography from the first quarter of the 6th century to the mid-13th century—actually disappeared from the Mediterranean during this period (Bellabarba, 1999). For instance, one of the authors, Furio Ciciliot, recently found a published image showing a galley with a square sail dating to the 9th century (Cassagnes-Brouquet, 2003: 28–9). Moreover, the introduction of the lateen sail in the Mediterranean was gradual and spanned a very long period. The appearance of a lateen sail in Mediterranean iconography dates to the 2nd century AD, and the disappearance of the square rig to around AD 525 (Bass, 1972: 154; Casson, 1994: 118). Be that as it may, the main question remains: how was this new technology diffused among the Mediterranean world? Many of these questions are addressed in detail in the following article, by Mark Polzer, which deals with rigging arrangements in the Ancient Mediterranean Sea.

Planks on frames

Another shift in shipbuilding technology started around the time of the disappearance of square sails from Mediterranean iconography. Since the Bronze Age ships and boats had been built in the Mediterranean by joining the edges of the hull planks together, either aligned with wooden dowels and sewn together with vegetable fibres, or fastened with pegged mortise-and-tenon joints, or using hybrids of these two techniques (Basch, 1972: 1–58). Frames were generally inserted after the planking was assembled and tended to play a lesser structural role. Hull strength resided largely in the hull planking, and this type of construction is generally referred to as shell-first or shell-based construction. From the early-6th century onwards, however, the structural role of frames seems to have increased incrementally, and by the 11th century frames were the main structural elements of at least one ship's hull. When the Serçe Limanı ship was built, at the beginning of the 11th century, a number of its frames were erected first, and planks were bent and nailed over them (Steffy, 1982; 1994: 89). This type of construction is known as skeleton-first or skeleton-based construction, and is less labour-intensive.

It is generally assumed that demographic and economic factors played a major role in the adoption of this new, skeleton-first way of building ships. During the period of transition from shell- to skeleton-based hulls, Europe suffered a series of economic and demographic crises, following the fall of the Western Roman Empire (Le Goff, 2000: 3–36, 195–254). It is highly probable that related socio-economic factors led the shift both from shell- to skeleton-based hull construction and from large square-rigged ships to smaller and faster lateeners. Latten-rigged ships were probably faster, and achieved better sailing angles to the wind. Could speed and manoeuvrability be two of the main reasons that made lateen sails apparently so popular in the early-medieval Mediterranean? These questions do not have simple answers, but have been formulated here in order to frame the aim of this paper, which is to try to understand technological change; in this case, the transition from the two- (and three-) masted lateen-rigged Mediterranean traders of the 14th century to the square-rigged, ocean-going ship.

Square sails and central rudders

Some time during the first decades of the 14th century a new type of ship appeared in the Mediterranean. It was called *cocca*, like the northern cog after which it was built. The name had already shown up in Liguria in 1190 (*cocius*), and became common throughout the 13th century (Ciciliot, 2005: 143). When they were first represented, in the early-14th century, *cocche* were characterized by a round hull, a round stempost, integrated castles, and a single mast mounting a square sail. Soon after, during the first half of the 14th century, most vessels adopted a central rudder. Needless to say, unlike the northern cogs, these ships were built with flush-laid planks fastened to pre-erected frames, in the skeleton-based manner of the Mediterranean ships of their time.

If we are to trust Giovanni Villani, a Florentine merchant and chronicler who travelled extensively between 1300 and 1307, the adoption of this new type of vessel was a quick and generalized phenomenon. About the year 1304 he wrote:

‘In questo medesimo tempo certi di Baiona in Guascogna con loro navi, le quali chiamano cocche, passarono per lo stretto di Sibia, e vennero in questo mare corseggiando, e feciono danno assai; e d’allora innanzi i Genovesi e’ Vineziani e’ Catalani usaro di navigare con le cocche, e lasciarono il navigare delle navi grosse per più sicuro navigare, e che sono di meno spesa: e questo fu in queste nostre marine grande mutazione di navilio’ (lib. VIII cap. LXXVII) (During this time, some people from Bayonne in Gascony passed the Strait of Seville with their ships, which they call *cocche*, and came into this sea, raiding and causing much damage; and from then onwards the Genoese, the Venetians and the Catalonians started sailing in *cocche*, which were much cheaper, and stopped sailing in large vessels because it was safer to sail in the smaller ships; and this was a great change of ships in our seas).

Although Villani says that Genoese, Venetians and Catalonians adopted *cocche* because they were both safer and more economical than the traditional two-masted lateeners (*navi grosse*), he implicitly acknowledged that galleys, although expensive, were still the best watercraft for commerce and war (Bellabarba, 1999: 81–93). On the same page of his *Cronica* Villani describes a naval battle which occurred in Flanders between the Genoese Rinieri Grimaldi (with 16 galleys and some *naves*) and Guido of Flanders. When the tide went down the Genoese galleys and *naves*

went to the high sea, and Guido thought he was the winner. However, when the tide rose once again, Grimaldi and his rowing galleys defeated the very large *cocca* of Guido’s fleet, which could not move as easily.

The merchant galleys from Genoa and Venice went on ploughing their traditional routes in the Mediterranean, into the Black Sea, and to the North Atlantic ports for many decades, but it seems that many of the larger two-masted lateeners, which carried most of the long-sea bulk trade around the Mediterranean, were replaced by the new *cocche* during the first decades of the 14th century.

The principal motives behind this technological change are not completely clear. The economic argument is a plausible one: commerce expanded and the size of ships grew, making the square sails cheaper. It is known that square sails with bonnets were easier to handle than the traditional lateen sails, at least on medium and large ships. Lateen sails had to be changed according to the wind force and could require a certain amount of effort to change tack. This manoeuvre entailed bringing the yard in, and rotating it near the foot of the mast, together with the sail and sheet. In large ships the yards and sails could be heavy, and the number of sailors required to handle them could be much larger than the average crew of an equivalent square-rigged ship, measured in terms of the number of sailors per ton of cargo transported. Galleys had a large number of sailors by definition, and could use them to change tack. Round-ships’ captains, on the other hand, may have been tempted to look at this new rigging arrangement as a solution which allowed considerable savings in terms of crew per ton of cargo carried. Fewer sailors cost less money, and left more space for cargo.

During the period of transition, the differences between *cocche* and *naves* can be seen in a manuscript in the Museo del Bargello of Florence, dated to c.1320–40, which shows an early representation of both the new *cocche* and the traditional *naves* lying side by side (Fabbri, 1999: 314–20; Ciciliot, 2005: 144). *Cocche* with one square-rigged mast and a central rudder are shown next to *naves*, which display two lateen-rigged masts and two side-rudders. The *naves* are large and high on the sea while the *cocche* are smaller. These two types of vessels represent two different solutions for two different tasks, but converged during the 15th century towards the three-masted ship of the European expansion.

These new three-masted ships incorporated and synthesized characteristics of both ship-types. The process of convergence is not clear and probably encompasses all the arguments expressed by scholars up to now (Bellabarba, 1999: 81–93). Evidence suggests that they may have evolved through two parallel lines, modifying both the *cocche* and the *naves*.

The technology to build large frame-based ships existed in the Mediterranean by the time the use of *cocche* became general. Large two-masted lateen-rigged *naves* are well known from written sources of the 13th century, when the Genoese promised to build large ships for the king of France, Louis IX. The largest of these ships was *c.*37.5 m long overall (*lunghezza di ruota in ruota cubiti*, or *goe*, 50), *c.*22.25 m long on the waterline (*lunghezza in carena cubiti* 31), and *c.*10 m in beam (*larghezza a mezza nave palmi* 40). It had two rudders, a mainmast 52 cubits high (*c.*39 m), and a mizzen-mast 49 cubits high (*c.*36.75 m) (Bonino, 1978: 9–28). Such a ship could carry about 1000 metric tons of cargo, and was as big as those of the 15th century.

Perfection, however, would arrive only after the adoption of two new features brought by the northern cogs. These new technological solutions were adopted gradually and partially by the builders of the large merchantman: the square sail and the central rudder. Square sails were probably used on small craft between the 6th and 13th centuries, for despite the lack of published images of square sails in this period, when they are represented once again in Mediterranean iconography they have lifts, just like the sails of the Romans, and unlike the sails of the northern cogs. Central rudders are represented from the mid-13th century onwards in northern Europe, and have been found on shipwrecks from the mid-12th century onwards. The earliest evidence for the central rudder is the Kollerup cog, in southern Denmark, dated to the 1150s (Hocker and Dokkedal, 2001: 16–17; Bill and Hocker, 2004: 43–54).

In the Mediterranean we know of a 1264 contract for a Genoese galley with one single rudder (probably central), at a time when cogs, although certainly already present, were not yet a well-known type of craft in the area (Ciciliot, 2005: 174). Technology being available, *cocche* grew in size during the 14th century. Early in that century there are mentions of *cocche* with more than one deck, and *cocche* loaded with 10,000 *cantari* of

alum, the equivalent to around 500 tons burden (Ciciliot, 2005: 144). It is also probable that Genoese ships influenced the design of northern cogs. Seafaring involves constant change and a diversity of solutions, and this helps us to understand why 14th-century Genoese documents mention *cocche* with two rudders, with lateen sails, or with large dimensions (Ciciliot, 2005: 142–7).

But the proliferation of square sails among merchant ships of the 14th century had yet another consequence. Some of the larger two-masted lateeners eventually adopted a different rigging arrangement, mounting a square sail on the foremast. The earliest representation of this square-lateen rigging dates to between 1336 and 1338 (Bellabarba, 1999: 85). Although the earliest representation of a three-masted square-rigged ship looks very much like a *cocca*, the adoption of the square-lateen rig by the *naves* created the conditions to shift both masts towards the stern and make space for a foremast. This would explain why the *mezzo masto*, lateen-rigged, became the mizzen mast (Mott, 1997: 139–46; Bellabarba, 1999: 87). In this dynamic environment, the new *quadra-latina* rig was clearly a step towards the development of the three-masted ship. This was nevertheless a very long evolution: the first representation of a three-masted, ship-rigged *nao* dates to 1409, almost a century later (Mott, 1997: 146).

Some scholars suggest that the development of the three-masted ship is also tied to the social and economic changes that followed the Black Death of the mid-14th century. The drastic reduction of the European population in only a few years generated a sudden concentration of wealth, as well as abrupt changes in labour and property prices. These changes must have impacted on European commerce networks, market sizes, and demand and supply equilibriums, as well as the overall quantities of goods exchanged. The 14th century was a time of change, and it is not easy to ascertain which changes of demographic, social, and economic factors played the most important roles in triggering the adoption of the *cocche*, which had replaced at least some of the larger two- and three-masted lateeners in some of the trade routes in the Mediterranean. In other words, the replacement of the traditional two-masted lateeners with lateral rudders by the new *cocche* is documented in harbour records and contemporary iconography, but its causes are not fully understood.

Modern engineering as an analytical tool

We believe that one useful contribution to a better understanding of this process lies in modern engineering, which allows us to look at ship's sturdiness, durability, stability and performance in a fairly objective way. Were *cocche* a revolutionary response to new challenges in the traditional network of trade routes? Were they assigned to the transport of new types of merchandises, along new trade routes? Or, on the contrary, did they replace the traditional lateeners on well-established routes, carrying the same cargoes? If so, what were the main advantages of these new ships in relation to the ones they replaced, besides the number of crew per ton transported? Were they much slower? How different were the characteristics of these new ships in terms of price, durability, cargo-capacity, cost per ton transported, intact stability, or performance under sail?

We must look at the differences between these two types of merchantmen and try to understand their advantages and disadvantages. The first step, which is the purpose of this paper, is to have a closer look at lateen-rigged merchantmen in the Mediterranean, for which we have a small but rather well-studied sample of shipwrecks (Table 1). We must keep in mind that lateeners did not disappear after the adoption of the *cocche*. One- and two-masted lateen-rigged ships were a common sight in the Mediterranean, both long before and long after the proliferation of the *cocche*. It is important to note that the *cocche* referred to by Villani were small- and medium-sized ships which nevertheless did not replace all the small lateeners, which probably transported most of the short-sea trade in the Mediterranean at the time. In fact, small and medium-size lateeners, the caravels, would be the vessels of choice of the Portuguese explorers in the 15th century (Pires, 1980; 1985).

Caravels probably have Arab origins and were already mentioned in mid-12th century Genoa as tenders of larger ships (Ciciliot, 2005: 139). They seem to have made their appearance on the shores of the Atlantic during the following century. During the 14th century caravels disappeared from Portuguese documents, reappearing in the following two centuries as the vehicles of choice for voyages of exploration, fishing and piracy, in both Portugal and Spain (Pico, 1964: 73–83). The designation lasted until the 18th century, although it must be noted that caravels were not always lateen-rigged ships (Domingues, 2004: 259–65).

As mentioned above, lateen-rigged ships had been sailing on Mediterranean trade-routes since at least the 2nd century AD, and would sail on that sea and along the coasts of the Atlantic Ocean until after the end of the Second World War (Iria, 1971: 152; Casson, 1994: 118). For instance, Portuguese two-masted *caïques*—thought to be related to the caravels of the 15th century—carried small cargoes of fruits and other cheap commodities along the coast of Portugal until the 1960s (Iria, 1963). Moreover, we know of one-masted *leudi* (built in Liguria c.1920–30) which carried cheese and wine until the same decade (1960) and are now used for local tourist cruises. One of them (c.15 m long) was built in Sardinia in 2005, the first for about 60 years. All of them have dimensions similar to those of the wrecks that will be described below.

Lateeners

Lateeners were cheap, versatile, and sturdy vessels. Their most obvious advantage over square-rigged vessels is that they can sail better into the wind. Their most obvious disadvantage is the relative complexity of the tacking manoeuvre, which generally requires more human power than the equivalent square-rigged vessels, and may have dictated the necessity of larger crews, which took up space and cost money. But this is only a general rule, for which there were exceptions. The Portuguese *caïque* did not actually change the yard when tacking, and could be handled by a small crew.

This study intends to look at a number of medieval lateen-rigged ships with a number of engineering tools, and to assess their quality as merchantmen in order to compare them with the square-riggers which eventually replace them. In the first phase the authors intend to look at five vessels, all believed to have been lateen-rigged. The quantitative analysis will focus on hydrostatic and stability calculations, resistance to advance, hull shape and performance:

Yassiada I

The Yassiada I shipwreck was found in 1958 by Peter Throckmorton, near the small coastal island of Yassiada, Turkey, and excavated between 1961 and 1964 by the University Museum of the University of Pennsylvania, under the direction of George Bass (Bass and van Doorninck, 1982: 9). It was dated to AD 625 or 626 based on its coin collection. The hull was reconstructed by J. Richard Steffy (Fig. 1).

Table 1. Basic characteristics of archaeologically-excavated lateen-rigged ships

Ship	Period (AD)	Estimated overall length	Estimated displacement	Construction	Framing pattern	Hull Shape	Reference
Yassi Ada II	c.400	20 m	—	Mortise-and-tenon joints	Frames and half-frames	Wine-glass	van Doorninck, 1976
Dor 2001/1	c.500	16 m	—	Planks on frames*	Floor timbers and half frames	Flat bottom, hard chine	Mor and Kahanov, 2006
Tantura A	c.500	12–15 m	—	Planks on frames*	—	Flat bottom, hard chine	Kahanov and Royal, 1996; Wachsmann and Kahanov, 1997; Kahanov, 2001
Saint Gervais II	c.600	18–20 m	—	Mortise-and-tenon joints in lower hull, planks on frames in upper works	Frames and half-frames	Wine-glass	Jézégou, 1985a; 1985b
Yassi Ada I	c.625	20–21 m	c.73 tons	Mortise-and-tenon joints in the lower hull	Short floor / long floor / half-frame	Wine-glass	Bass and van Doorninck, 1982; Steffy, 1994
Tantura F	c.700	12–16 m	—	Planks on frames*	Floors and futtocks	Flat bottom	Wachsmann and Kahanov, 1997; Barkai and Kahanov, 2007
Tantura B	c.800	20–26 m	—	Planks on frames*	Frames and half-frames	Wine-glass	Wachsmann and Kahanov, 1997; Royal and Kahanov, 2000
Bozburun	c.874	14–15 m	c.55 tons	Planks on frames (wooden dowels on edges, connecting planks)	L-shaped floors, alternated	Wine-glass	Harpster, 2005a; 2005b
Ille Plane C	c.900	—	—	Planks on frames?	—	—	Ximenes, 1976
Agay A	c.900	20–25 m	—	Planks on frames*	Floor timbers and half frames	Flat bottom	Visquis, 1973; Joncheray, 1976; Darmoul, 1985; Jézégou <i>et al.</i> , 1997
Agay B	c.900	9–10 m	—	Planks on frames*	Floors and futtocks	Flat bottom	Visquis, 1973; Joncheray, 1976; Darmoul, 1985; Jézégou <i>et al.</i> , 1997
Batéguier	c.900	20–25 m	—	Planks on frames*	L-shaped floors, alternated	Flat bottom	Visquis, 1973; Joncheray, 1976; Darmoul, 1985; Jézégou <i>et al.</i> , 1997
Serçe Limanı	c.1025	14–15 m	c.57 tons	Planks on frames	L-shaped floors, alternated	Flat bottom	Darmoul, 1985; Jézégou <i>et al.</i> , 1997 Bass <i>et al.</i> , 2006
Norman Wreck A	c.1150	18 m	—	Planks on frames?	Floors and futtocks	Flat bottom	Purpura, 1985; Ferroni and Meucci, 1996
Norman Wreck B	c.1150	8–9 m	—	Planks on frames?	—	Flat bottom	Purpura, 1985; Ferroni and Meucci, 1996
Culip VI	c.1300	16–17 m	c.56 tons	Planks on frames	Floors and futtocks	Flat floor, round chine	Prieto and Raurich, 1989
Contarina I (14)	c.1300	20–21 m	c.94 tons	Planks on frames	Floors and futtocks	Round bottom	Bonino, 1978
Les Sorres (15)	c.1350	10–11 m	—	Planks on frames	Floors and futtocks	Round bottom	Raurich <i>et al.</i> , 1992
Logonovo (14)	c.1400	c.10 m	—	Planks on frames	Floors and futtocks	Round bottom	Bonino, 1978
Contarina II (14)	c.1550	20–21 m	—	Planks on frames	Floors and futtocks	Round bottom	Bonino, 1978

* The final study of the Bozburun hull (Harpster, 2005a; 2005b) showed that only full disassembly and detailed analysis would allow a final judgment on these shipwrecks.

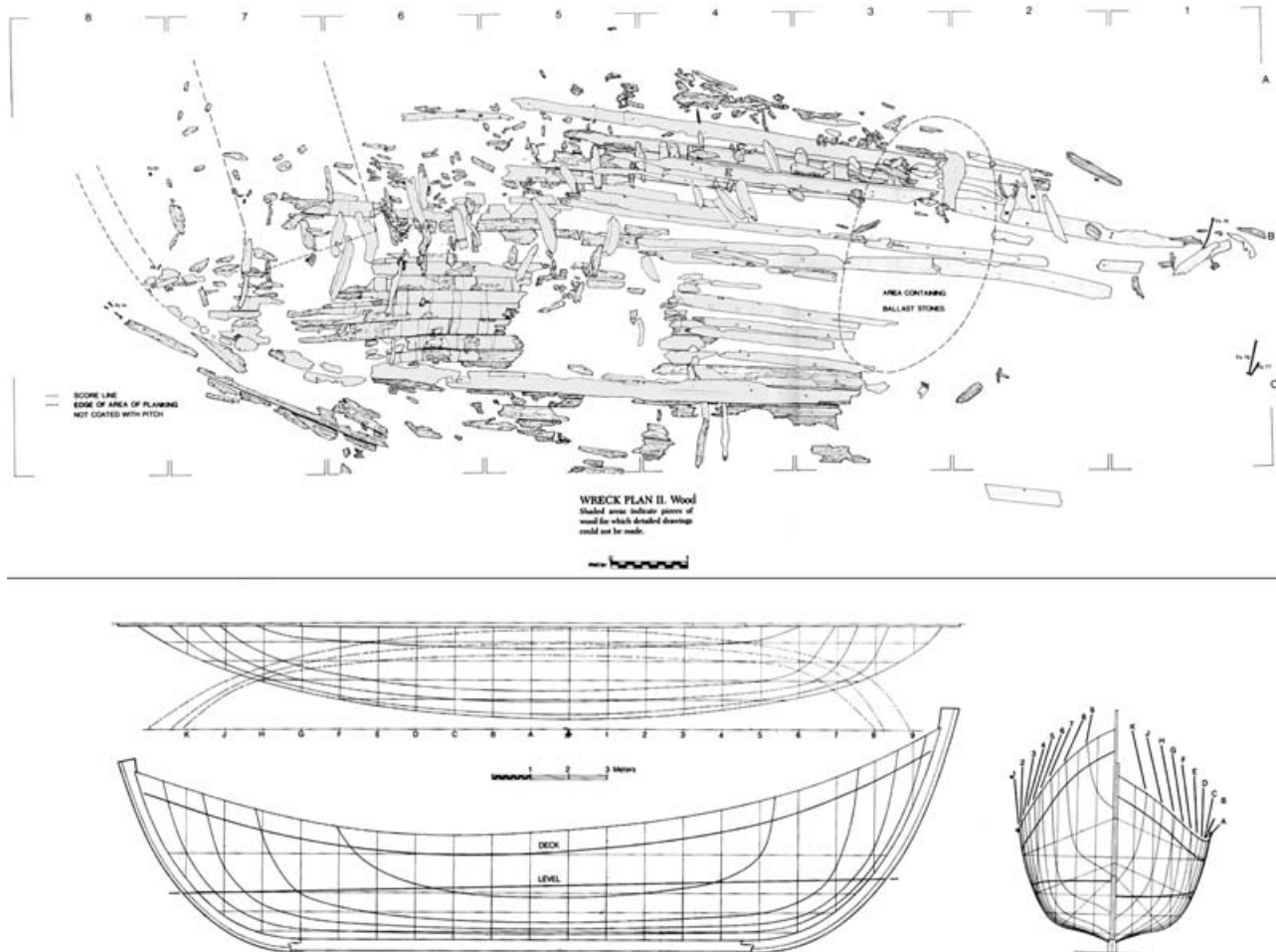


Figure 1. Yassiada 7th-century hull remains and reconstruction. (Steffy, in Bass and van Doorninck, 1982: 45, 76, reproduced with permission)

Bozburun

The ship from Bozburun was shown to George Bass by sponge divers in 1973, and excavated by Texas A&M University's Institute of Nautical Archaeology, under the direction of Fred Hocker, between 1995 and 1998 (Hocker, 1995; Hocker and Scafuri, 1996; Hocker, 1998a; 1998b; Harpster, 2002; 2005a; 2005b). It was dated to AD 874 by dendrochronology (Harpster, 2005a: 7), and yielded a cargo of around 900 amphoras, together with a small collection of personal artefacts. Around 35% of its hull was preserved and a reconstruction has been proposed by Matthew Harpster (Fig. 2).

Serçe Limanı

This shipwreck was shown to George Bass by sponge divers at Serçe Limanı, Turkey, in 1973, and was excavated by the Institute of Nautical Archaeology and Texas A&M University, under

George Bass' direction, between 1977 and 1979 (Bass *et al.*, 2006: 52). It was dated to around AD 1025 based on the artefact collection and known chronologies (Bass *et al.*, 2006: 290). The hull was reconstructed by J. Richard Steffy (Fig. 3). It was a small, flat-bottomed lateener 14.55 m long, with a beam of 5.2 m and a depth of hold of 1.6 m. With an estimated weight of the hull and gear at around 21 tons, the Serçe Limanı ship was probably rated a 35-tonner and displaced 57.27 tons at the load waterline (Bass *et al.*, 2006: 167, 169). The weight of the hull alone was estimated by Tomás Vacas at 15.95 tons (Vacas, 2006: 34).

Culip VI

Found in 1987 at Cala Culip, Catalonia, this shipwreck was excavated by the Centre d'Arqueologia Subaquàtica de Catalunya (CASC) between 1988 and 1990, under the direction of

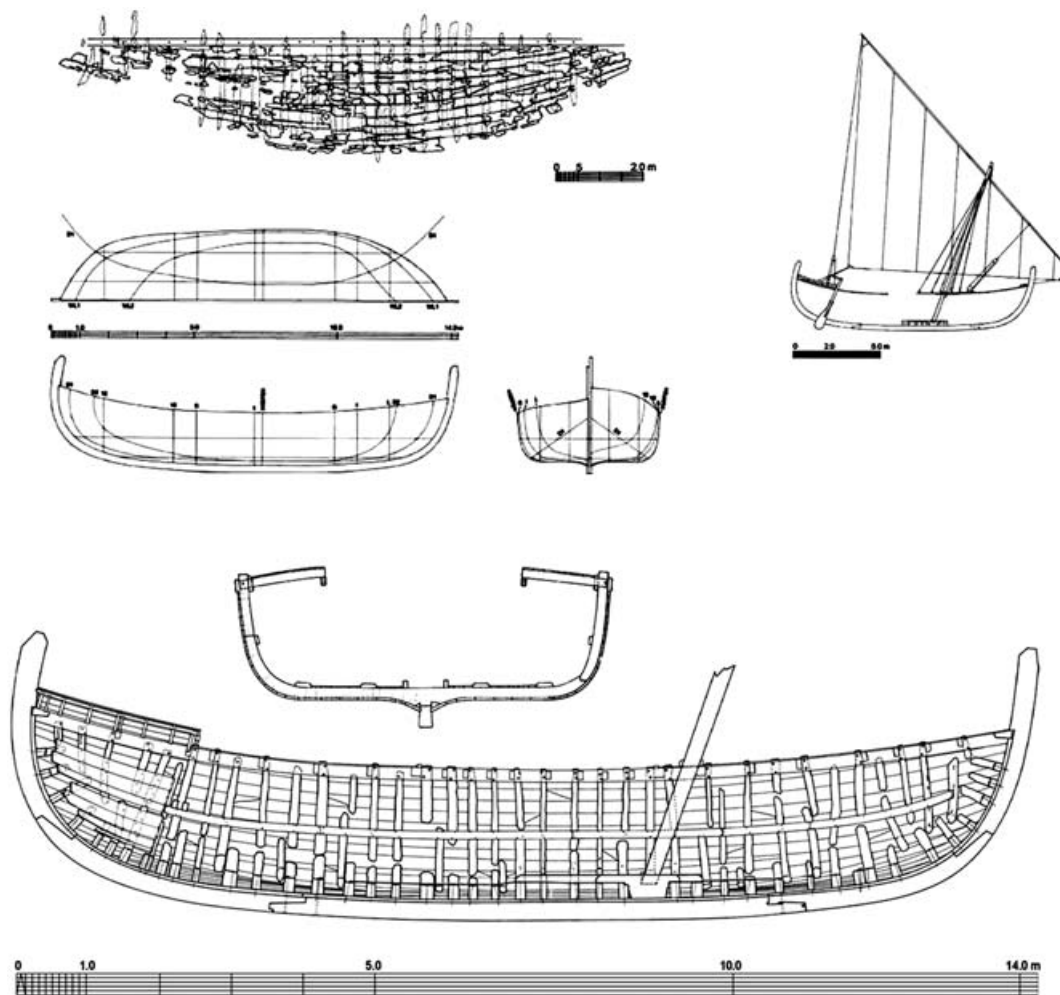


Figure 2. Bozburun hull remains and reconstruction. (Harpster, 2005a: 220, 464, 465, 466, reproduced with permission)

Xavier Nieto Prieto (Prieto and Raurich, 1989). Situated in shallow waters, its cargo was probably salvaged soon after the ship's loss and did not yield many clues to the reconstruction of its route. It was dated to around AD 1300 based on the artefact collection (Prieto and Raurich, 1989: 235–6). The hull was reconstructed by Eric Rieth, based on the measure of the flat midships and the distance between the mast-step and one of the ship's extremities, thought to be the bow (Prieto and Raurich, 1989: 191–201). Based on the proportions of the contemporary vessel Contarina I, it was reconstructed as a small short-sea trader of 16.35 m length overall, a beam of 4.11 m and a depth of hold of 2.06 m. The hull weight was estimated at *c.*16 tons, and the cargo capacity at *c.*40 tons. When fully loaded it displaced 56 tons (Fig. 4).

Contarina I

Found in 1898 at Contarina, near Rovigo, north-east Italy, during the excavation of a canal, this ship was dated to around AD 1300 (Bonino, 1978: 9–28). It was preserved along an area measuring 19.62 m by 5.20 m, and to a height of 3.4 m. Although the timbers were not preserved after its recording, a replica of this ship has been made. As reconstructed it measured 20.98 m overall, had a beam of 5.20 m and a depth of hold of 2.46 m, making it similar to but slightly smaller than the vessel described in the Venetian manuscript known as *Libro di marineria*, or *Fabrica di galere*, whose original (the Michael of Rhodes manuscript) dates to 1436 (Fig. 5).

In a second phase the authors will try to extend this analysis to a larger number of lateeners. The third and last phase of this project will deal with

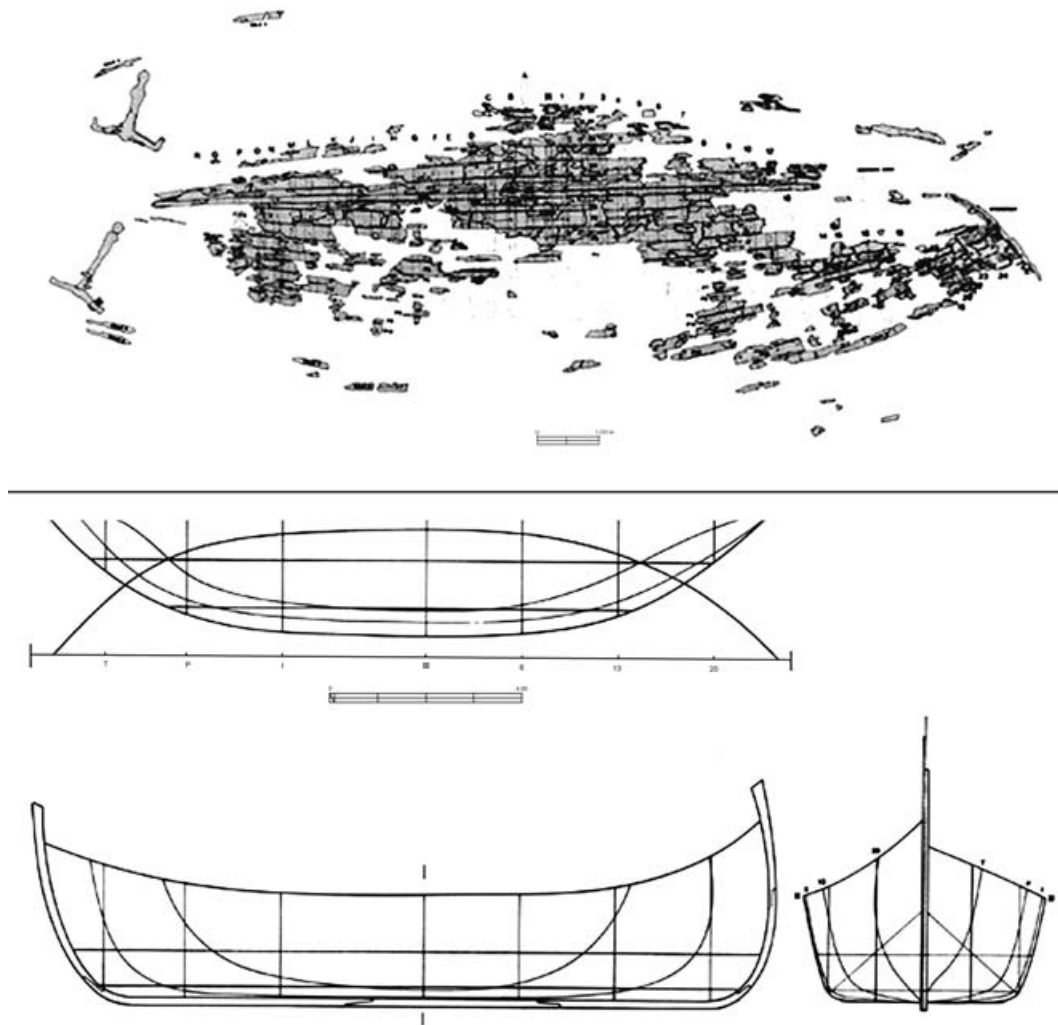


Figure 3. Serçe Limani hull remains and reconstruction. (Steffy, in Bass *et al.*, 2006: 82–3, 166, reproduced with permission)

early square-rigged vessels, mainly from the north of Europe. The size of this sample will ultimately depend on the availability of data regarding both lateen- and square-rigged vessels.

Conclusions

The ships presented above are a very small sample of the enormous diversity of merchant craft which must have sailed the Mediterranean between the early-7th and the 14th century, the period in which lateeners seem to have been the most common watercraft (Fig. 6). During the millennium that followed the sack of Rome by the army of Alaric in AD 410, Europe saw enormous changes, invasions and movements of populations, the slow decline of the Byzantine

Empire, the rise and fall of the Islamic Umayyad and Abbasid empires, the political reorganization of Western Europe, the Carolingian Renaissance, the Viking invasions, and the beginning of the Italian Renaissance. However, it was not until the beginning of the Italian Renaissance that Europe experienced a real intellectual revolution. As Bertrand Russell wrote, although turbulent in practice, the Middle Ages were marked by a passion for legality and a precise theory of political power. There were no great inventions, nor were there far-reaching technological changes (Russell, 1945: xiii–xxiii, 491–503).

As far as shipbuilding techniques go, however, things were quite different. Although we have a small sample of shipwrecks from this period—especially small when we only consider those

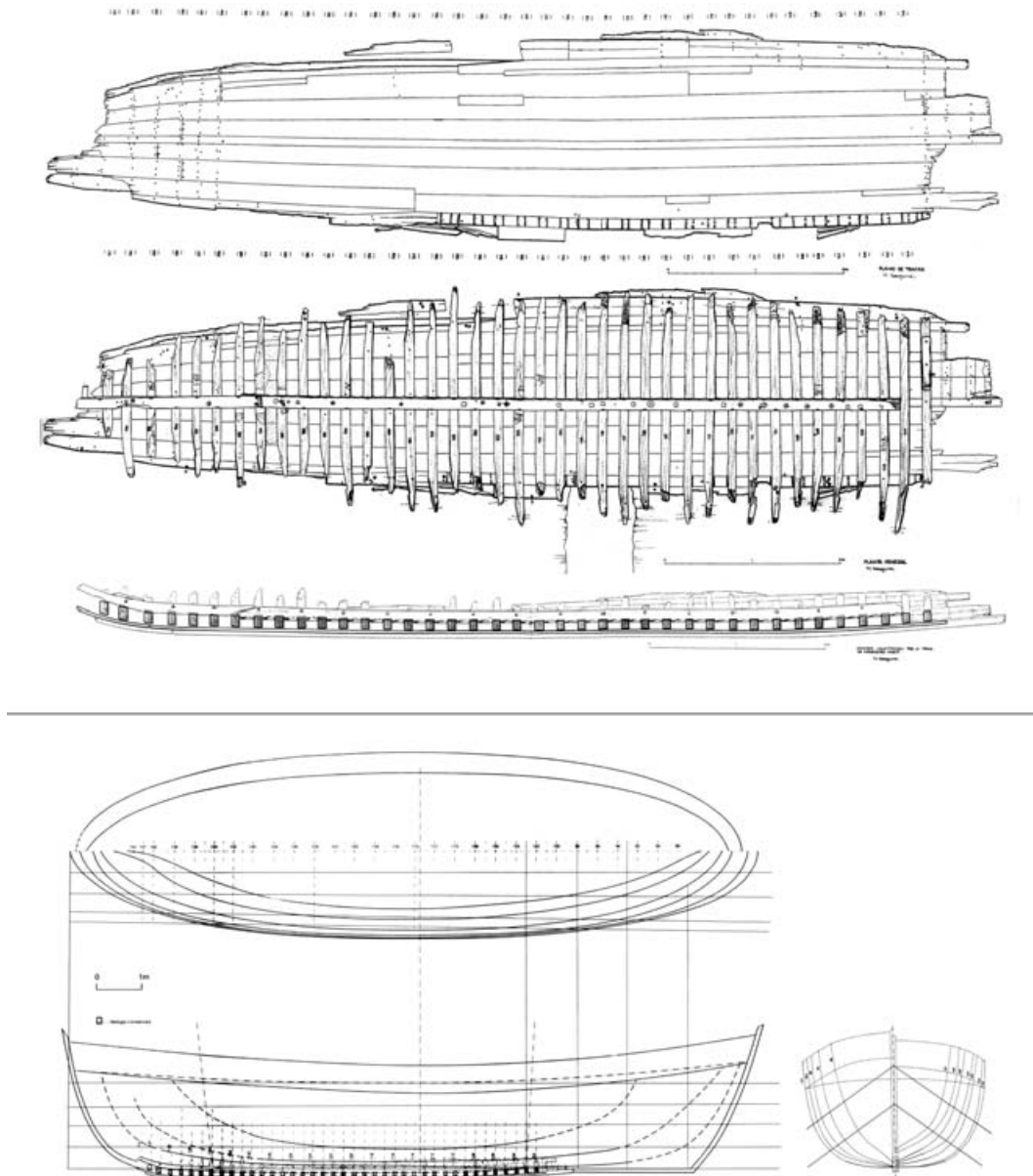


Figure 4. Culip VI hull remains and reconstruction. (Rieth, in Prieto and Raurich, 1989: 140, 197–8, reproduced with permission)

which have been fully excavated, disassembled and studied—we know that the way in which ship's hulls were assembled changed drastically during this period, both in their structural philosophy and in their construction sequence (Steffy, 1994: 84). It is therefore interesting to take a closer look at a small sample, and to lay the basis of what hopefully will be a wider work of analysis of the transition from lateen to square rigging. As reconstructed, all these ships have in common their rigging arrangement and their

small to medium size. This approach—tentatively quantitative, even considering a small sample of conjectural reconstructions—seems to the authors especially interesting considering the number of recent finds of ships from this period: at least 25 shipwrecks in Istanbul between 2005 and 2007 (pers. comm. Cemal Pulac, 2007), 25 shipwrecks at Tantara and Dor, Israel (Wachsmann and Kahanov, 1997; pers. comm. Kahanov, 2006), and at least 16 shipwrecks at Olbia, Sardinia, Italy (Riccardi, 2006: 312–15).

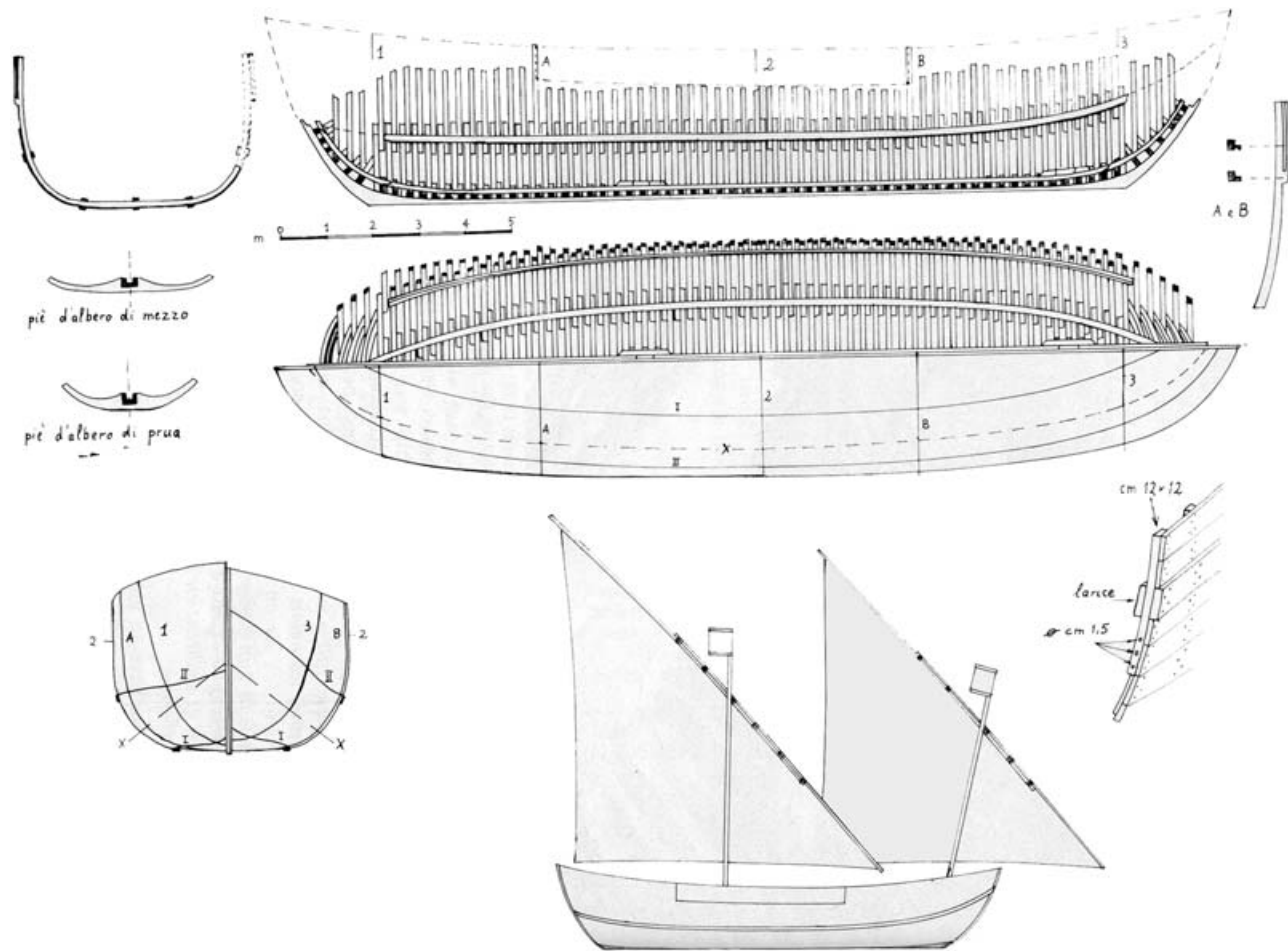


Figure 5. Contarina I hull remains and reconstruction. (Bonino, 1978: 14, reproduced with permission)

One possible outcome of this study is a look at the relationships of deadweight to capacity, and of displacement to crew numbers. Shipwrights and ship-owners certainly thought of these things because they determined the profitability, or even the sustainability of their business: how many tons in capacity could one increase in each particular type of craft, for example, before needing two more hands on deck? All resistance calculations presented in a forthcoming paper will neglect the action of the side-rudders. We know next to nothing about the shape and suspension arrangements of these ships' rudders, but we are sure that their efficiency implied some added drag. It will also be interesting to understand the relationship between length-to-beam ratios and the routes sailed and cargoes carried. For the time being the authors can only compare these hulls in terms of tonnage, midship,

block, prismatic and waterplane coefficients, as well as wet surface and possible sail areas.

Future analysis should include estimations of crew sizes, autonomy (for instance, how much water could they carry?), and speed. It is likely that a systematic study such as this one, extended over time to the increasing number of shipwrecks being found and recorded to good archaeological standards, will allow us to build a database of medieval vessels from which better conclusions can be extracted. It is difficult to understand why the *cocche* were adopted so fast and so widely (if we are to believe Villani). One future avenue of research will be archival research in harbour records in order to inventory and organize chronologically the niches filled by this new type of craft, as well as to understand, at any stage, which were the perceived advantages of *cocche* over two-masted lateeners with similar tonnages.

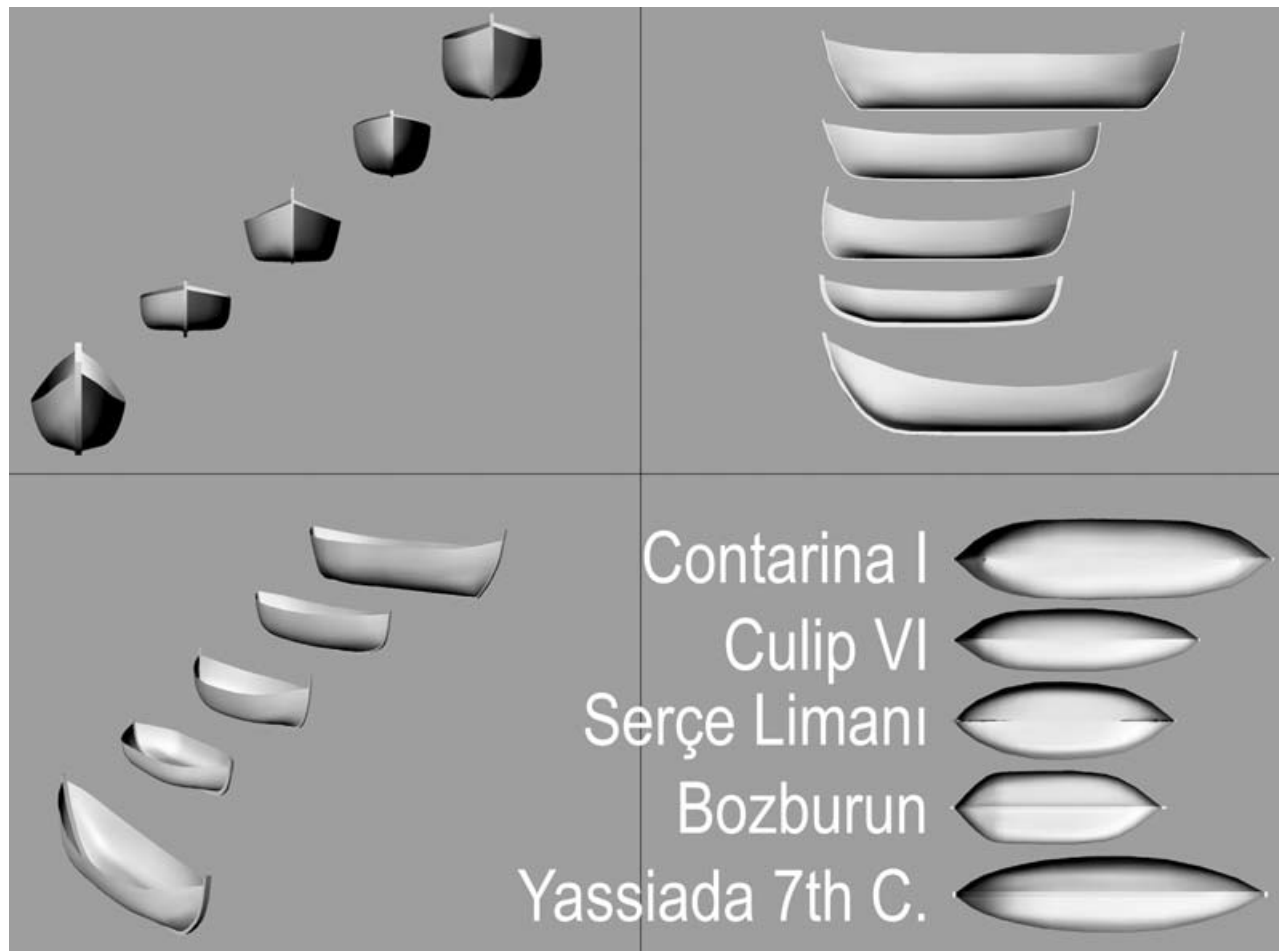


Figure 6. The five hulls under analysis. (Tomás Vacas)

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