The Last Field Season on the Pepper Wreck: A Preliminary Analysis of the Hull

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It is almost as satisfying to reach a milestone in a significant project as to look back on a completed job well done. The fourth and final season on the Pepper Wreck (Site SJB2) finished in August 2000, at least in terms of the field work. The ship, believed to be *Nossa Senhora dos Mártires*, sank at the mouth of the Tagus River at São Julião da Barra just outside Lisbon on September 15, 1606. INA joined the Instituto Português de Arqueologia (IPA), which sponsored the excavation through its underwater archaeology department, the Centro Nacional de Arqueologia Náutica e Subaquática (CNANS). In this last season, we were also sponsored by MARCASCAIS, the company that manages the new marina of Cascais, where our boats were stationed.

The Pepper Wreck, thought to be the remains of an early seventeenth-century Portuguese East Indiaman, was discovered in 1994. Excavation, begun in 1996, yielded a collection of thousands of artifacts, as well as part of the hull structure (see *INA Quarterly* 26.4, 12–15). Our objectives in 2000 were to complete the recording of the remaining hull timbers to permit study, analysis, and partial reconstruction of the hull.

Some of the timbers were raised and some left in situ, protected from the strong dynamics of the sea under a layer of sandbags. We inspected a new area scarcely one hundred meters from the SJB2 site, where timber remains had been spotted last winter by our longtime collaborator and close friend Carlos Martins. This experienced diver has found most of the sites around São Julião da Barra, and has been our best guide to archaeological sites on that rough bottom. Unfortunately, a layer of sand no less than two meters thick, as well as a strong current, prevented us from reaching the remains in the three trial trenches we opened.

As always happens in underwater archaeology, the conservation and analysis of the artifacts will go on for a long time, as will reconstruction of the hull. Indeed, the hull has shown to be the most important artifact on this site. Although the remains consist only of a very small portion of the bottom of the ship, these timbers, with construction marks engraved on their faces, speak volumes.

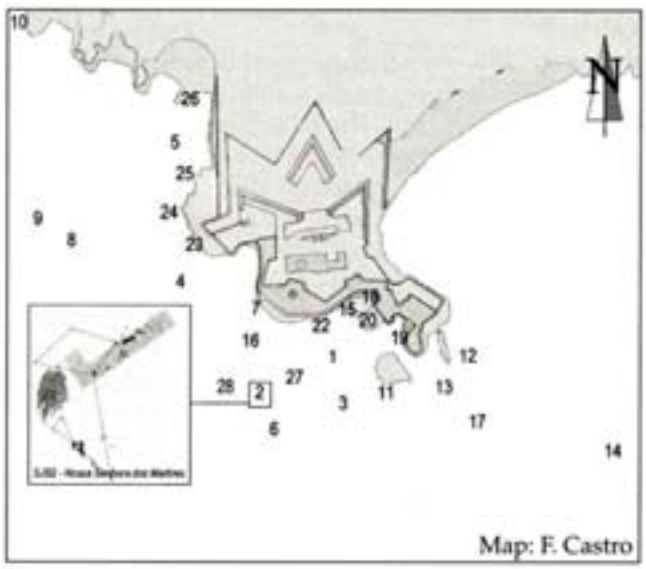


Fig. 1. *The SJB2 shipwreck site.*

The wreck is located within an area that might be termed an archaeological complex, a relatively small stretch of sea bottom containing several shipwrecks (fig. 1). The strong dynamics of the sea and the annual shift of sediments have combined to mix the artifacts from several wrecks. This site is an interesting and rich ship graveyard, but it is also a true nightmare for archaeologists. The material culture represented in the collection of artifacts encompasses a period of over 350 years. According to a CNANS database, many wrecks were lost at the "mouth" of the Tagus, a general designation that encompasses a very extensive area. Fortunately, the area of the fortress of São Julião da Barra is small and well defined. The official documents refer to most vessels wrecked here specifically as being lost off the fort, rather than at some less precise designation. These known sites date from the late sixteenth century to the middle twentieth century (table 1). The records often correspond with and explain the provenience of artifacts retrieved or located near São Julião da Barra.

The first challenge of this study has been the identification of the Pepper Wreck, designated as SJB2 in the map of the complex. One important clue was a thin layer of peppercorns, covering the hull timbers. These extended over a very large area that contained a very homogeneous collection of artifacts from the late sixteenth century and early seventeenth century. The Chinese, Japanese, and Burmese pottery found in the pepper layer can be dated to this same period. It bears a great resemblance to the ceramics collection of the Manila galleon *San Diego*, wrecked in the Philippines in 1600. The porcelain, from the Wan-Li period, is from the 1590s and 1600s. An astrolabe found within the site bears the date of 1605, establishing the earliest possible year for the wreck.

The evidence we have uncovered points to one particular vessel, presumably built in Lisbon: *Nossa Senhora dos Mártires*. It was employed in the Carreira da India, the lengthy voyage between Goa and Lisbon. *Mártires* wrecked off São Julião da Barra in 1606 on a return voyage from Cochin on the Malabar coast of India. The proposed identity

Table I. *List of Wrecks in São Julião da Barra*

Year	*Ship*	*Provenience*	*Comments*
1587	*San Juan Baptista*	Lisbon	Near the fortress
1606	*Nossa Senhora dos Mártires*	Cochin, India	Under the walls of the fortress
1625	*São Francisco Xavier*	Cochin, India	Presumably near, south of the fortress
1704	English vessel (70 cannons)		Near the fortress
1733	*Union*	St. Malo, France	Near the fortress
1753	Dutch vessel		Presumably near, east of the fortress
1802	English vessel		Near the fortress
WW I	*Maria Eduarda*	Viana, Portugal	Presumably near, west of the fortress
1966	*Santa Mafalda*		Near the fortress

(Source: CNANS Database)

of the wreck is reinforced by the presence of a large quantity of peppercorns, indicating a bulk cargo of pepper, and therefore an Asian origin for the trip of the wrecked vessel. Study of the woods utilized–cork oak (*Quercus suber*) and umbrella pine (*Pinus pinea*)–and the scantling dimensions leave no doubt that this is a Portuguese-built hull.

During the sixteenth and seventeenth centuries, a small fleet would leave Lisbon for India almost every year, making this voyage the longest regular route of its time. The Portuguese designed and built the ships specifically to sustain a six-month-long trip. They had to offer enough space for their crew and passengers, together with their victuals, and leave enough free space for the large amounts of merchandise brought back on the return trip. Their main cargo–peppercorns–was a very light commodity to store in the holds, especially if these vessels were to carry heavy artillery on the upper decks. To maintain stability, they had to carry a large amount of ballast, creating an even greater demand for space in the holds. In light of these factors, it seems incredible that the average late sixteenth-century India route *nau* had a keel length of less than thirty meters!

Illustrations of early seventeenth ships are scarce and generally inaccurate, so we are lucky to have a few late sixteenth and early seventeenth-century texts that discuss the conception of the *nau*. Four texts have been especially important in the reconstruction of the hull remains. The first is the *Livro da Fabrica das Naus*, written in Portuguese by a priest and adventurer named Fernando Oliveira around 1580. It translates a previous Latin work of his, *Ars Nautica*, whose manuscript (dated to around 1570) is in the University of Leiden. The second is an anonymous list of the timbers necessary to build a three-decked, 600-ton *nau* for the India route. This is part of a codex in Lisbon's National Library, dating from the 1590s, known as the *Livro Náutico*. The third is a manuscript titled *Livro Primeiro de Arquitectura Naval*, providing an incomplete "recipe" for building a four-decked *nau*. This was written around 1610 by João Baptista Lavanha, engineer of the kingdom, mathematician, and author of many other books. The fourth is perhaps the most interesting and elusive of them all, since the author is virtually unknown in spite of the magnificent self-portrait and signature with which he opens his book. It is called *Livro de Traças de Carpintaria*, dated 1616, and signed by a Manoel Fernandez, shipwright.

From these texts, we have a fair idea of how these vessels were designed and built. However, when it comes to details, we have few certainties, many doubts, and a great deal of ignorance about the shipwrights' methods, techniques, and practices. The ability to answer such questions is why nautical archaeology is such an important contributor to maritime history.

The remains of the SJB2 hull consisted solely of a portion of the keel, eleven frames, an apron, and an area of planking covering around twelve by seven meters (fig. 2). In addition, the marks of the iron spikes with which the planks were nailed to the frames showed a clear pattern. This helped us to determine the position of another fourteen frames.

Before starting the reconstruction of the hull, I performed a series of checks on the accuracy of the 1997 1:10 site plan, drawn by reducing a large number of 1:1 drawings made over Plexiglas slates on the bottom. I compared the measurements of the timbers raised in 1999 and 2000 with their representations in the plan. I found a discrepancy of five centermeters over a distance of twelve meters in the longitudinal direction, representing an error of less than 0.5 percent. There was a difference of three cm in the transverse direction, representing again less than 0.5 percent error in the overall measures. An independent team checked the position of each spike hole in the planking on the north half of the wreck. This was only partially done on the southern half, leaving a few—not very important—doubts here and there.

The presumed positions of the fourteen vanished frames marked on the planking were strongly reinforced by the existence of a number of interesting remarks on the floors and futtocks. Once analyzed, the positions and meanings of these marks give us a very clear picture of the principles that guided the conception and construction of this vessel.

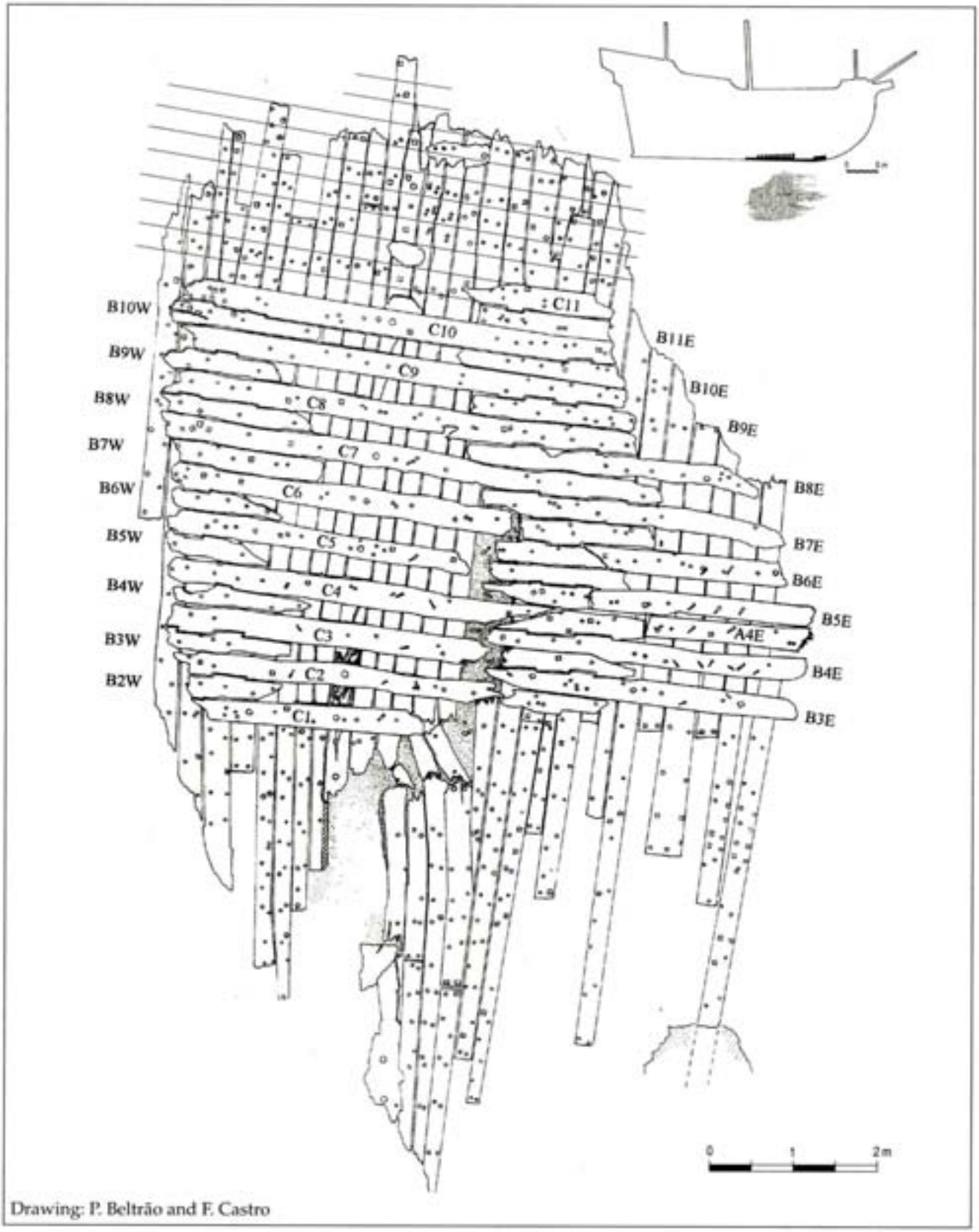


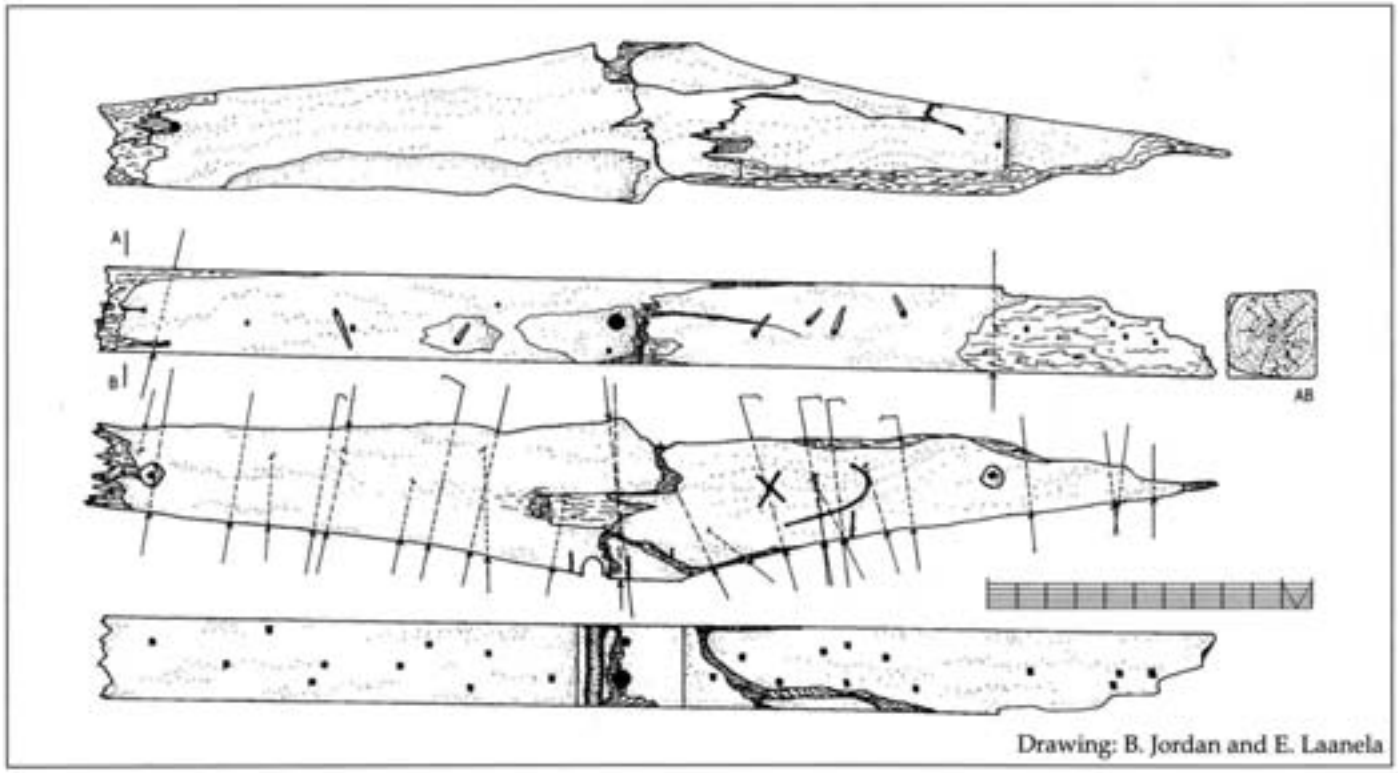
Fig. 2. *The presumed* Nossa Senhora dos Mártires *as it lay on the seabed.*

As mentioned above, eleven contiguous floor timbers were preserved over the keel, growing in their molded dimensions from the north to the south, in the direction of the bow. They show four types of marks: a sequential numbering in Roman numerals; a series of marks that seem to have no precise meaning, presumably resulting from scratching during the construction process; a series of vertical lines, marking the edges—in Portuguese *astilhas*—and the axis of the keel; and a series of lines marking other construction features. Of this last group, four vertical lines are clearly placed on what I believe to be the turn of the bilge points, and another three deserve a closer look, since their meaning is not clear at this point (fig. 3). Two are also vertical marks on the aft face of floor timbers C2 and C3, and the third is a line on the base of floor C3.

All four texts mentioned above describe a shipbuilding process generally known as skeleton-first, or frame-based, as it is perhaps more accurate to say. In this method—typical from the Mediterranean tradition and already many centuries old in the sixteenth century—the central section of the hull was defined through a certain number of pre-designed and pre-assembled frames that were mounted over the keel. The widest frame (or frames) of this group was generally placed in the center of the central portion and called midship frame(s), or master frame(s). The last of these pre-designed assemblies, fore and aft, were called tail frames. The fore and aft ends of the hull, called *delgados* in Portuguese, were defined by a series of ribbands that ran from post to post over these central, pre-designed frames. This ensured that the planking would have smooth runs and would not endure unnecessary stresses during its lifetime. At the same time, this system guaranteed that the bow and stern would have beautiful and fair shapes, cutting the water easily, and avoiding any turbulence around the rudder. The remaining frames may have been formed and fitted only after all the ribbands were set in place. In this system of construction, shipwrights did not depend on drawings to define the shape of the pre-designed frames. These were obtained from a rectangular mould and set of gauges, called *graminho*. These determined the rising of the bottom and its narrowing, from a maximum width at the flat midship frame to the 'V' shaped minimum width and maximum rise at the tail frames.

Following a very simple procedure, the total rising or narrowing was divided by the number of floor timbers over which it was to be distributed by a simple algorithm called *besta* (cross-bow) in Portuguese, the equivalent of the Italian *mezzaluna*. This algorithm was used to build a *graminho*, with the full scale measures to be added or subtracted from the main mold of the midship floor (fig. 4).

I measured the molded dimensions of the floors over the keel, and plotted their heights together with their respective sequential numbers. The spike marks on the northern planking clearly show a set of three floors placed together,



Drawing: B. Jordan and E. Laanela

Fig. 3. *Floor timber C2. Note all four types of marks mentioned in the text: 1—the Roman numeral "X," 2—a round groove, probably just a scratch, 3—the axis and edges of the keel, and 4—a vertical line to port side.*

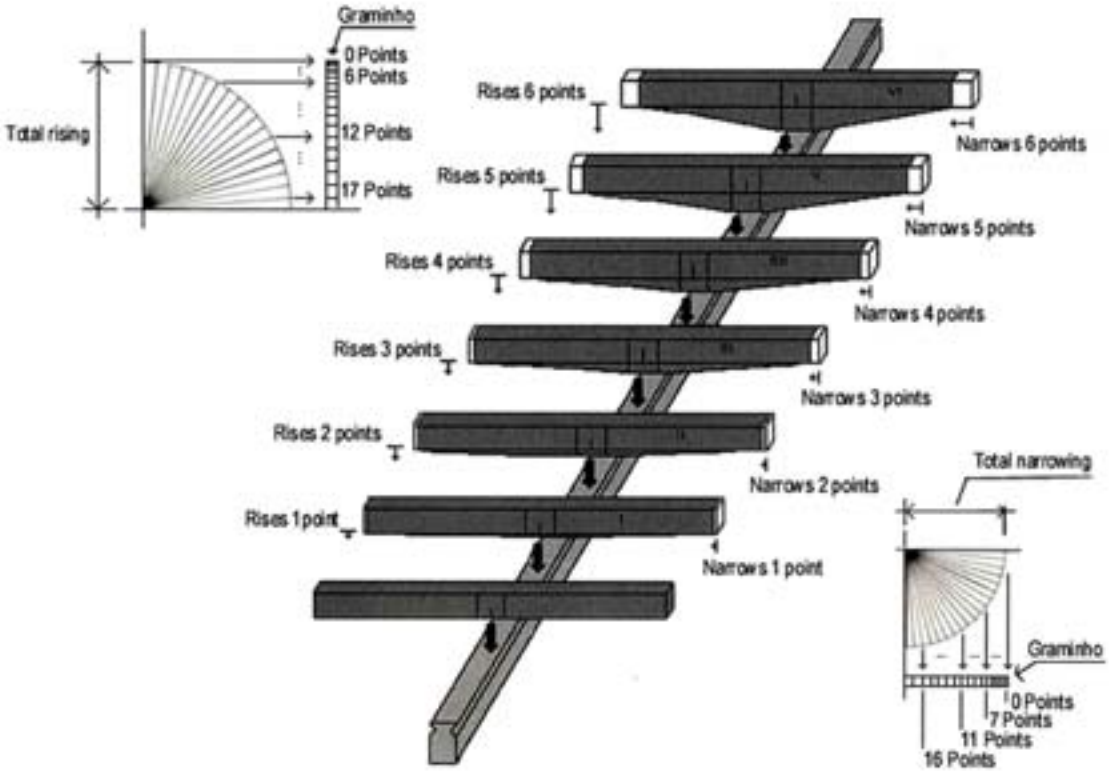


Fig. 4. *Rising and narrowing pre-designed floor timbers. Computer generated representations have become a great aid to the archaeologist to depict theories in a speedy—but sometimes a less than perfect—drawing. Drawing: F. Castro*

to which should be assigned the number zero, considering the numbering order observed in the preserved examples. My reconstruction produced a series of values that followed very closely the rising of the bottom recommended in Oliveira's *Livro da Fabrica das Naus* for a *nau* of eighteen *rumos* of keel (one *rumo* is 1.54 meters, so eighteen *rumos* equals 27.72 meters). According to Father Oliveira, an India route *nau* must have eighteen *rumos* of keel, three midship frames, and eighteen pre-designed frames before and abaft these three master frames (fig. 5). The total rising of the bottom should be the equivalent to one room-and-space (the distance from an edge of one frame to the same point on the

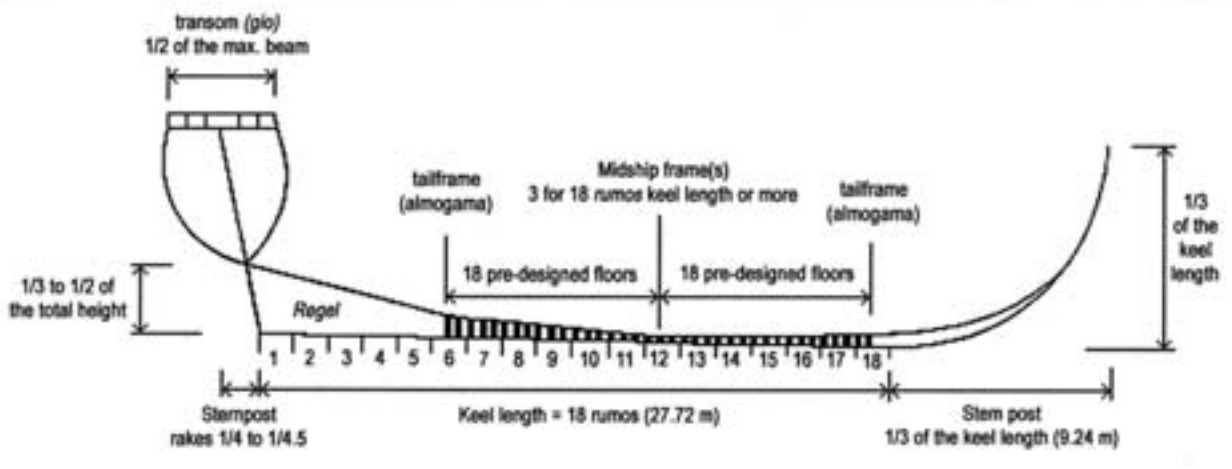


Fig. 5. *A computer generated representation of the rising of the bottom, after Father Fernando Oliveira. Drawing: F. Castro*

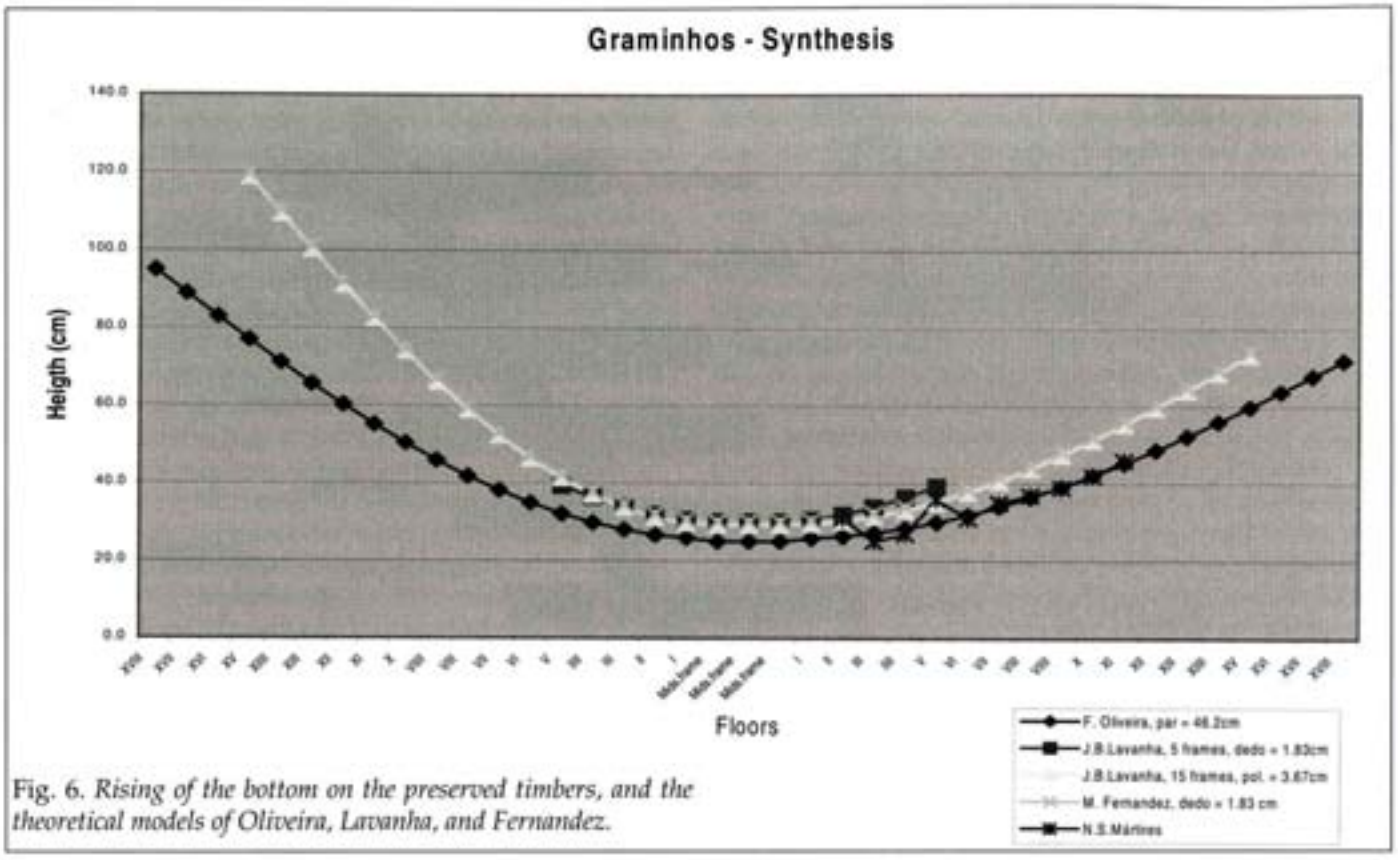


Fig. 6. *Rising of the bottom on the preserved timbers, and the theoretical models of Oliveira, Lavanha, and Fernandez.*

next frame) to the bow, and one and a half room-and-space to the stern.

I tried varying the number of pre-designed frames in my reconstruction, as well as the value of the rising, since the other sources suggested different designs. *Livro Náutico* determined that an India *nau* should have one single master frame, and seventeen pre-designed frames before and abaft the master frame, and rising of three *palmos de goa*—one *rumo* equaled six *palmos de goa*—to the stern (the rising in the direction of the bow is not mentioned). Lavanha's *Livro Primeiro* indicates only one master frame and five pre-designed frames fore and aft, but mentions an old method with fifteen pre-designed frames to each side of a single master frame. Fernandez's *Livro de Traças* indicates also fifteen pre-designed frames to each side of three master frames.

After considering all possible sets of values, it still looked very much like Oliveira's pattern was the formula used in constructing the bottom of what we presume to be the *nau Mártires* (fig. 6). Following this line of reasoning, I then tried to relate some of the vertical marks observed on the floors with a few theoretical curves drawn from Oliveira's book for the narrowing of the bottom. Again, if considering three master frames, as seems to have been the case, four consecutive marks match within 1 cm the expected values for the turn of the bilge. Both these values of the flat of the midship frames, or *plão*, and the total narrowing, are perfectly within the values indicated by Father Fernando Oliveira.

At the present time I have no explanation for the remaining three marks. Two of these consist of vertical marks, either less well preserved or less deeply engraved on the aft sides of floor timbers C2 and C3. The third is visible on the base of floor C3, and has no clear meaning at this stage.

Recording and reconstructing the shape and size of the thirty-nine central frames is only the first step in the reconstruction of the entire hull. The next step will be to analyze the curvature of the preserved futtocks, and determine how the midship section was designed, at least to the water line. To achieve this I am being helped immensely by Dr. Thomas Vogel of the TAMU Mathematics Department. From there, it will be easy to extrapolate a plausible shape of the ship, at least the submerged portion, and an acceptable full volume of the hull. The positions of the hatches, pumps, capstans, and mast steps are well defined in the texts mentioned above. They also describe the size and shape of the fore and aft castles, the size and rake of the main mast, and the length of the remaining masts, as well as some of the yards. Many questions remain, however, and many more will certainly appear as the reconstruction work evolves. This is why the wreck has been such a thrilling object to study, and why, when it is finished, it will provide a basis for analyzing and understanding similar vessels.

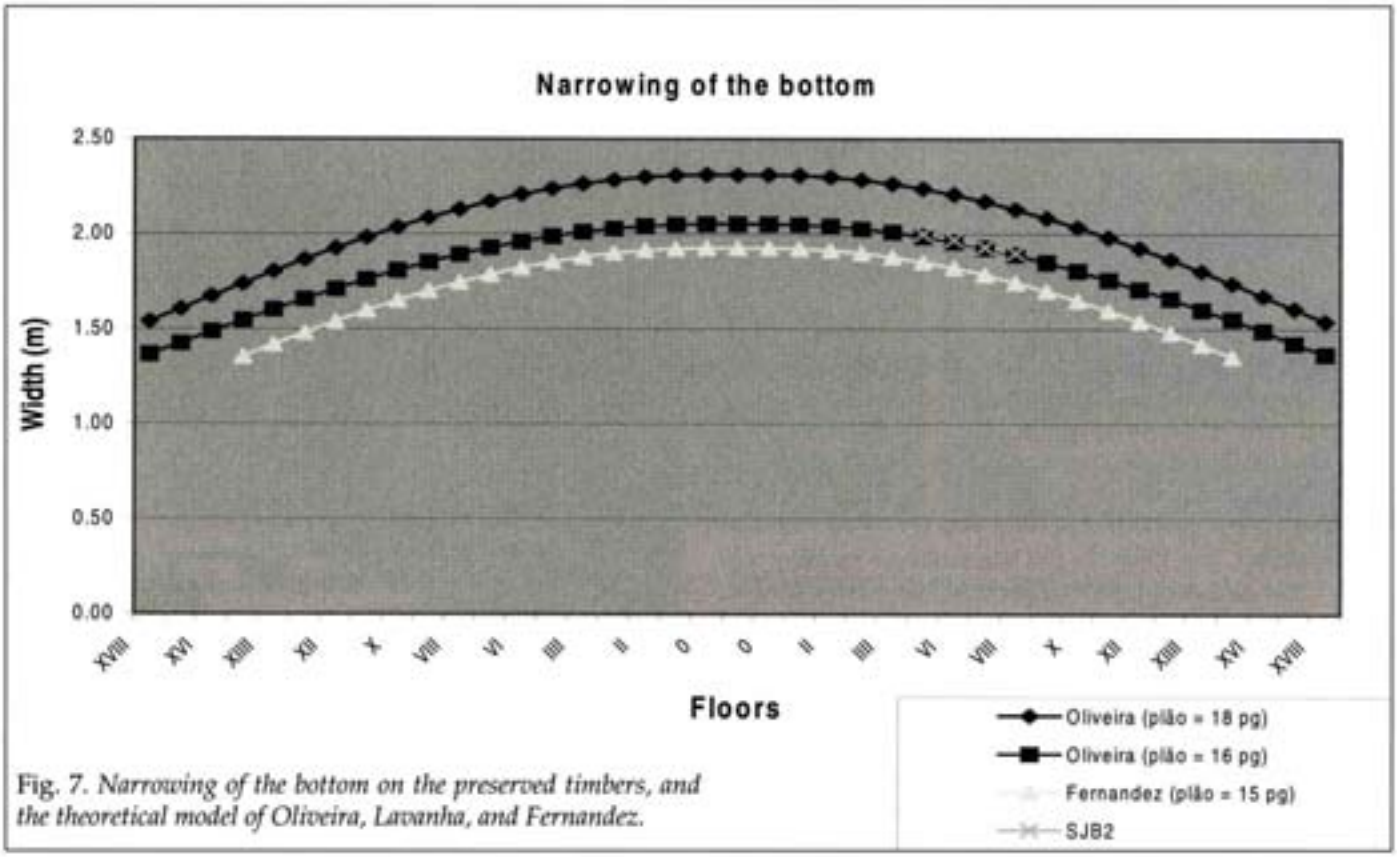


Fig. 7. *Narrowing of the bottom on the preserved timbers, and the theoretical model of Oliveira, Lavanha, and Fernandez.*

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Suggested Readings

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