The remains of a 14th-century shipwreck at Corpo Santo and of a shipyard at Praça do Município, Lisbon, Portugal

FRANCISCO ALVES ▮ ERIC RIETH ▮ PAULO RODRIGUES

On June 3, 1996, the remains of the stern part of a wooden ship were discovered during archaeological excavations in Corpo Santo Square, Lisbon, in an area where a large ventilation shaft was planned for the city's new subway line (Figs. 1 and 2a)[1]. It was the second discovery of its kind in the area within the period of one year. It followed the discovery, in 1995, of a ship dated to the late 15th or early-16th century near Cais do Sodré Square, a few hundred metres away (Rodrigues, 1998). The remains were at depths corresponding to the former levels of the banks of the Tagus River.

The discovery of the remains at Cais do Sodré and Corpo Santo closely followed the identification, in 1994, of a mid-15th century shipwreck in the Ria de Aveiro, subsequently designated Ria de Aveiro A (Alves, 1998a). The stern of this vessel had similar characteristics to that of the Corpo Santo ship (Figs. 2b and 3). As a result, within only two years, two shipwreck finds from almost the same period and exhibiting similar construction details were excavated in Portugal.

According to their radiocarbon dates, the Corpo Santo remains appear to be the oldest of the three ships, followed by Ria de Aveiro A and Cais do Sodré. A wood sample from the Corpo Santo hull planking produced a date of 620 ± 40 years BP, as described in the following summary: "*In calibrating the date obtained using the curve of Stuiver and Person (*Radiocarbon, 1993, 35.1, p. 1-23) *intersections were obtained in 1315, 1347 and 1390 cal AD and the following intervals: for 1 sigma: 1302-1401 cal AD; for 2 sigma: 1292-1412 cal AD*[2].

The Corpo Santo ship, sectioned by the circular, concrete wall of the ventilation shaft, was found at 1,02 m above sea level, at a depth of 4,47 m below the present ground surface. It was found resting on its starboard side with the keel oriented east-west and the vessel's stern toward the west. Only the stern part was recovered, but it seems likely that the rest of the ship extends under the buildings around the square.

The structure was found resting on a level surface of beach sand and some artefacts were found underneath the hull. These included a leather shoe sole found adhering to the planking[3]. The excavation of the sedimentary layers above the structure brought to light abundant remains, especially ceramics, characteristic of the 15th and 16th centuries. This rich evidence was not unexpected as the excavation zone coincides with a riverside area known as *Cata-que-farás*, immediately west of the zone formerly occupied by the Ribeira das Naus — a well-known naval shipyard since the late Middle Ages. This zone, formerly occupied by the Arsenal da Marinha, is now the headquarters of the Portuguese Naval Forces[3].

The Corpo Santo remains were removed as a whole and deposited in the Centro de Operações de Arqueologia Subaquática (COAS), informally created in 1996 within the scope of the Comissão Instaladora do Instituto Português de Arqueologia and IPPAR for the development of an underwater archaeology project within the programme of the Pavilion of Portugal for Expo'98 (Alves et al., 1998; Castro, 1998)[4]. The structure was subsequently disassembled[5], drawn and photographed in the facilities of COAS (Figs. 4-6).

FIG. 1 – Location of the Corpo Santo shipwreck. A: Corpo Santo; B: Praça do Município; C: Cais do Sodré.

FIG. 2A – View of the Corpo Santo shipwreck *in situ*. *Photo: F. Alves.*

FIG. 2B – View of the stern end (heel) of the Corpo Santo shipwreck. *Photo: F. Alves.*

FIG. 3 – View of the stern end (heel) of the Ria de Aveiro A shipwreck. *Photo: F. Alves.*

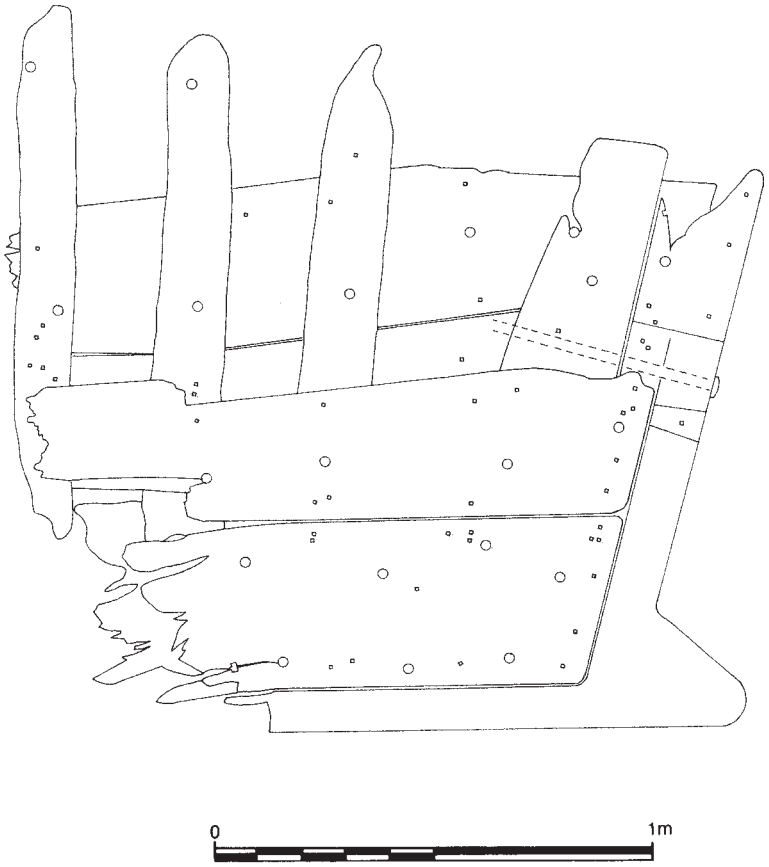

FIG. 4 – Drawing of the port side view of the Corpo Santo shipwreck.

FIG. 5 – View of the of the Corpo Santo shipwreck with the port-side planking disassembled, the stern knee and heel being visible. *Photo: P. Rodrigues.*

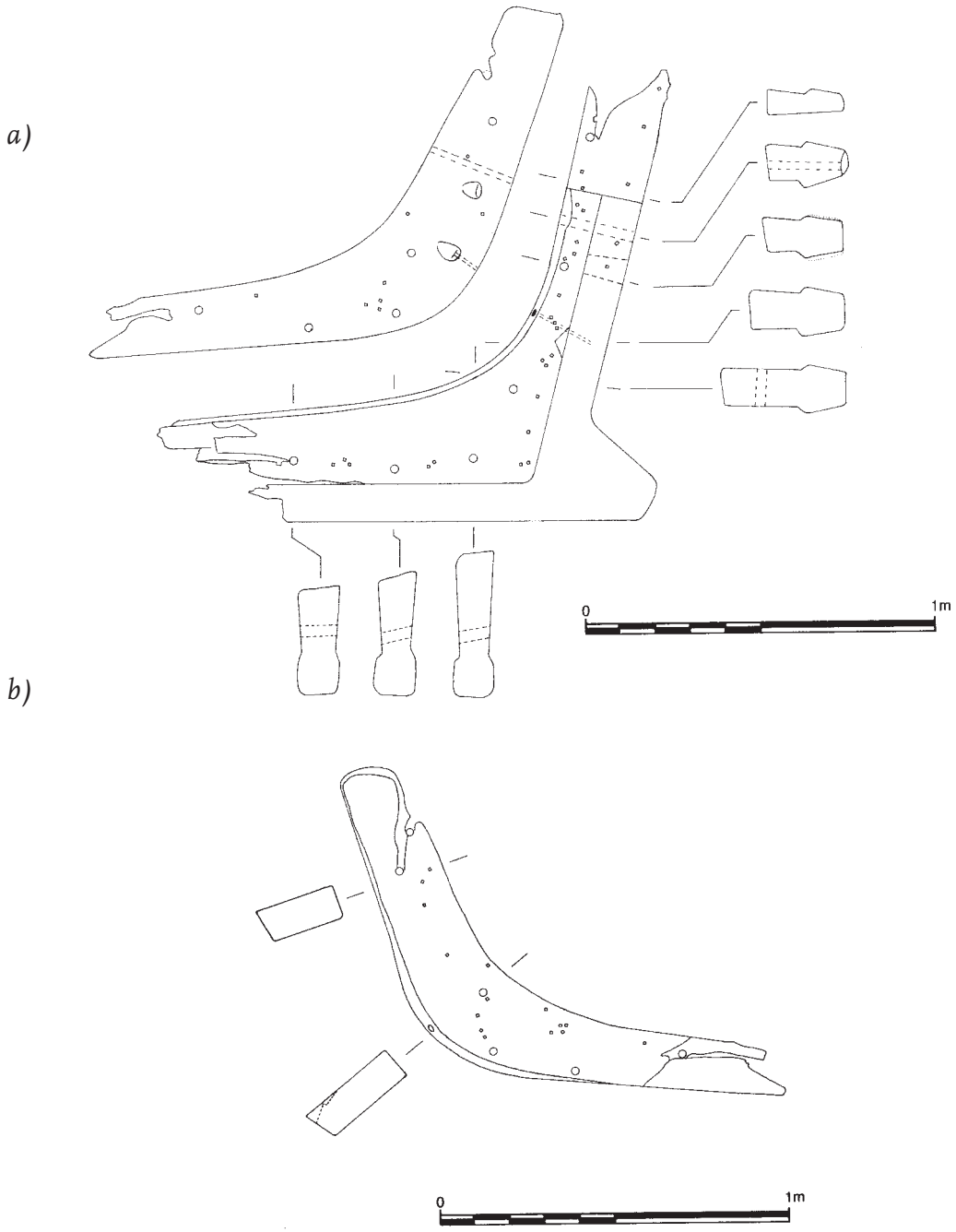

FIG. 6 – Drawings of the heel and the stern knee of the Corpo Santo shipwreck: *a)* view of the port side with cross sections of the heel; *b)* view of the starboard side with cross sections of the stern knee.

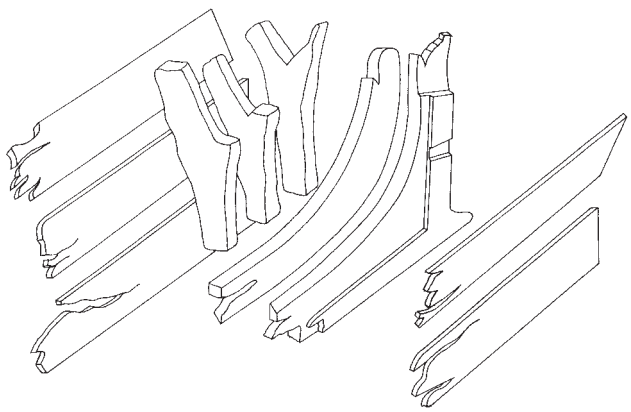

FIG. 7 – Exploded view of the remains of the Corpo Santo shipwreck.

Detailed description[5]

The Corpo Santo remains consist of ten pieces (Fig. 7), all incomplete and with broken ends. Five pieces belong to the ship's longitudinal and transversal framing — the heel timber and the stern knee, plus three Y-shaped floor timbers. The five remaining pieces are outer hull planks — two from the port side and three from the starboard side, including the garboards from either side.

The entire recovered structure is 1,8 m long fore-and-aft, 1,6 m high in its original vertical position and 0,6 m in its maximum transversal width.

The heel

The heel, a separate timber forming the aft end of the keel, has a skeg at its end in the form of a characteristic protuberance *(...) over which the rudder rests* (Lavanha, 1608-1616/1996, p. 45) (Fig. 8).

The heel was preserved over a length of 1,4 m and a height of 1,25 m. The angle formed by the longitudinal axis of the sternpost in relation to the longitudinal axis of the keel is 78°. However, it was not possible to evaluate the geometric formula or proportions on which the timber's shape would have been based.

Interestingly, this angle is not incompatible with the standard values found in classical works of Portuguese naval architecture. Sternpost angles of 77° and 78° are illustrated in the *Livro da Fabrica das Naos* by Fernando Oliveira (1580/1999, p. 82, 99). In the *Livro de Traças de Carpintaria* by Manoel Fernandez (1616/1995), they average around 74° (p. 77, 82), although the sternpost of a *galizabra*, as illustrated, was only 66° (p. 109). These values are relatively close to the values of 72° and 73° observed in the presumed *San Juan* (Tuck and Grenier, 1985, p. 40). However, the Corpo Santo sternpost angle is much closer to vertical than that of the contemporary ship Ria da Aveiro *A*, which rises at 63° (Alves, 1998a). In several other examples of the Iberian-Atlantic shipbuilding tradition (Oertling, 1989c, 1998), similar values to those of Ria de Aveiro A are found: 65° in the *San Esteban* (Rosloff and Arnold, 1984, p. 291), 63° to 65° in the Western Ledge Reef wreck (Watts, 1993, p. 113), and 60° in the *San Diego* (L'Hour, 1994, p. 147).

The angle of the heel of the *San Diego* is the lowest ever documented, either archaeologically or in the shipbuilding treatises of the period, although Garcia de Palacio (1587) does indicate values between 64° and 65° (Soto, 1988, p. 137) or 70° (Soto, 1988, p. 125; Serrano, 1991, p. 145). In turn, Valadares mentions the value of 67° (Soto, 1988, p. 145), and Mendonza that of 71° (Serrano, 1991, p. 149).

While no correlation can be made between the angles of the sternposts and the dates of the examples under consideration, one important related point merits discussion. The *San Juan*, *San Esteban*, Western Ledge Reef and *San Diego* wrecks, as well as the information from Oliveira, Palacio or Fernandez, all post-date the Middle Ages, belonging to the 16th and early 17th centuries. As such, all may be associated with a square or transom stern which, according to written and iconographic evidence, developed toward the end of the 15th century[6]. Since the Corpo Santo and the Ria de Aveiro A shipwrecks predate this crucial event in shipbuilding history, their structure presumably featured a round stern. In these conditions, any comparison with later sources seems inconclusive.

Another essential parameter is that of the transverse thickness (sided dimension) of the heel timber along its horizontal and vertical parts, which were scarved respectively to the keel and to the sternpost. Three measures were taken: across the outboard face, next to the rabbet and across the inboard face (see the respective sections in Fig. 6*a*). On the heel's lower, hori-

zontal part, the three measures were, from the stern forward: 11, 11 and 11 cm, 11, 12 and 11 cm and 11, 12 and 11,5 cm. These widths, taken at five points from bottom to top along the upper part that connected to the sternpost, were 10, 13,5 and 11 cm, 10, 13 and 11 cm, 8, 12 and 10 cm, 7, 12,5 and 10 cm and 5,7 and 7 cm (this last value is in the area of the scarf).

These values are similar to those of the equivalent part of the Ria de Aveiro A ship, but are significantly smaller than the comparable dimensions of any known example corresponding to the Iberian-Atlantic tradition, which range from 16 cm recorded at Highborn Cay (Oertling, 1989b, p. 246) to 30 cm on the *San Diego*, whose keel was reinforced by a false keel (L'Hour, 1994, p. 147).

The moulded dimension of the heel, measured from its outboard edge to the rabbet line, is 11 cm at the timber's lower (keel) end and 12 cm at its upper (sternpost) end. The rabbet itself has a depth of 1,5 to 1,7 cm. On the timber's horizontal (keel) part, measurements were taken of the angle of the back rabbet, the surface against which the planks are laid. At the sections indicated in Fig. 6*a*, the plane formed by the back rabbet lay at 85°, 83° and 82° to the keel's lower face. Similarly, on the upper (sternpost) part, the back rabbet lay at 88°, 85°, 85°, 84° and 79° to the heel timber's outboard face. At these same sections, the sided dimension of the back rabbet (the seating surface of the planking, from the rabbet to the timber's inboard edge) is 31, 24 and 19 cm along the timber's lower (keel) part and 23, 14, 10, 10 and 9 cm along the upper (sternpost) section.

The function of the heel timber is explicitly described by Lavanha: "*(...) the keel (...) cannot be an entire timber, because one of such size cannot be found, and in any case the heel and touch have to be whole and, a straight timber being found, it cannot have the curves that are required for the said heel and touch (...)* (p. 43 and 44) and *(...) the heel, which is the corner that the sternpost makes with the keel is made from one slab that may have its shape and which may be convenient for that and, thus, with diligence it may be sought and set aside because it is a very main part and very important part for the ship (...)*" (p. 44, 45).

This type of stern construction is also frequently seen in iconography and archaeology of ships from other periods and construction traditions. We find it, for example, in northern Medieval Europe, for example the Bremen cog, and in the post-medieval Mediterranean tradition of southern Europe, as in the Genoese *Lomelina* (Guérout, Rieth and Gassend, 1989). The same may be said concerning the use of the skeg. In the Iberian-Atlantic tradition, this detail is found not only in the Corpo Santo and Ria de Aveiro A ships and in the Portuguese treatises of Lavanha and, especially, Fernandez, but it is present also in the presumed *San Juan* (Grenier, 1988) and the *San Diego* (L'Hour, 1994). However, it is absent in the *San Esteban* (Rosloff and Arnold, 1984) and the Cattewater wreck (Redknap, 1984).

Among the morphological details of the Corpo Santo heel timber, we note the presence of a longitudinal scarf in the upper extremity on the port side, intended for the assembly of the heel with sternpost (Figs. 6a, 9 and 10). The horizontal edge of this scarf is 40 cm from the preserved top of the piece and has a depth of 5 cm. It forms an obvious parallel with the *San Esteban*, a Basque ship lost on the coast of Texas in 1554 (Rosloff and Arnold, 1984, p. 290, fig. 3), though here the scarf is lower, being just above the base of the heel.

Lavanha described this type of assembly between the heel and the sternpost: "*(...) About the heel, in continuing the sternpost, in pieces (if it cannot be whole) which are joined with their scarfs as with the first with which the said sternpost is joined to the heel and it would have to be much considered that it does not open either more or less than 12 palmos from the right angle as said above (...)*" (p. 46).

Turning to the fasteners, three transversal iron-spike holes were found on the upper part of the heel timber, where the sternpost was joined to the heel timber. The nails were aligned

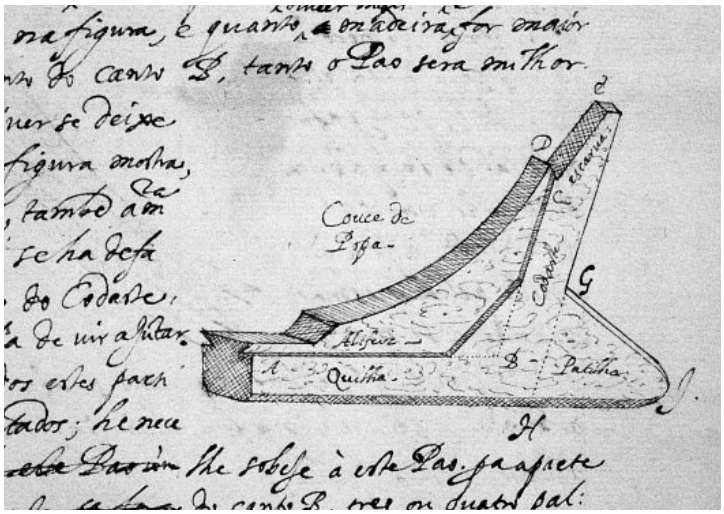

FIG. 8 – Representation of a heel in the work by João Baptista Lavanha, *Livro Primeiro de Architectural* (1616) (f1 63).

FIG. 9 – Stern view of the Corpo Santo shipwreck. *Photo: P. Gonçalves.*

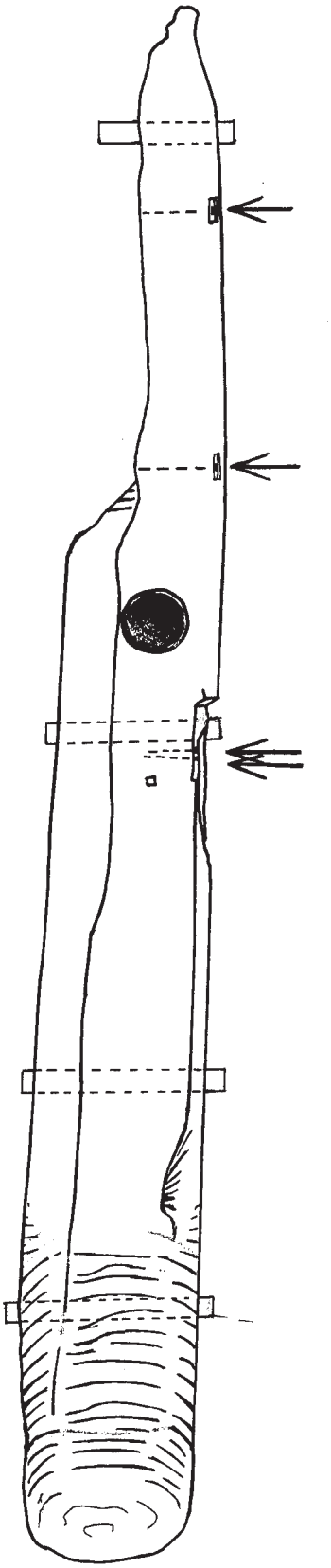

FIG. 10 – Drawing of the rear surface of the heel of the Corpo Santo shipwreck.

FIG. 11 – View of the reinforcement nailing of the vertical scarf of the part of the sternpost of the heel of the Corpo Santo shipwreck.

obliquely relative to the heel's axis. The lowest nail is 4 cm from the rear surface of the stern and 13 cm from the middle hole. This second nail is 2 cm from the surface of the stern and 9 cm from the third nail, which is 1 cm from the surface of the stern and 2,5 cm from the top. While all the nail holes are square in section, one had a rectangular head that left an impression 3 cm by 3,3 cm and the other two a circular impression with diameters of 3 cm and 2,5 cm.

This reinforcement nailing pattern is also discussed by Lavanha, who stated *(...) these pieces are joined with scarfs in the same manner as the keel and with the same* Anielado *spikes they are nailed as is shown in the following figure (...)* (p. 45). This feature, as illustrated in Lavanha's manuscript (fo. 63v; see Fig. 11), is reflected in the archaeological evidence from Corpo Santo.

Finally, a channel 8 mm deep reveals where the gudgeon strap lay. The channel passes horizontally around the heel's upper (sternpost) part, ending on each side at the rabbet where the hull planks were butted. Measuring 11,5 cm in length and 6 cm in width, the channel's upper edge lies at about 55 cm below the preserved top of the timber.

The sternpost knee

The sternpost knee is an L-shaped internal reinforcement for the heel that is fixed to the heel's inboard faces and serves as a rising deadwood upon which the Y-shaped floor timbers are seated (Lavanha, 1608/1616/1996, p. 59). Of note in the sternpost knee from Corpo Santo is the slight rising of its lower plane that sits on the heel, which is accentuated in the curved central area (Figs. 5 and 6). This feature remains unexplained for the time being. As well, this contact surface between the sternpost knee and the heel slants downward to the starboard. This characteristic, no doubt designed to drain moisture from the joint, acts in concert with an iron nail that is introduced obliquely so as to traverse the joined timbers at an angle precisely perpendicular to the slanted joint and thus optimise the strength of the assembly (see Fig. 5, related cross section).

In its original position, the preserved height of the stern knee is 1 m and its length, 1,3 m. Its moulded dimension at the five sections indicated is 16,5 cm, 21 cm, 37 cm, 34 cm and 22 cm. At each of these same sections, the respective breadths (sided dimensions) of the inboard and outboard surfaces are 9 and 13 cm, 11 and 12 cm, 10 and 11 cm, 10 and 11 cm and 10 and 11,5 cm.

The sternpost knee has a round hole 45 cm from its upper end where a bolt 2 cm in diameter passed through the knee and the sternpost. Immediately below this bolt hole is another hole 2,4 cm in diameter and 7 cm deep, with the remains of an iron encrustation, presumably corresponding to the attachment bolt for the (unpreserved) Y-shaped floor timber P1 that was, therefore, nailed in a manner different from the other floor timbers. Square nail holes about 1 cm to a side are observed on the surface of the sternpost knee. These nail holes, indicating where the Y-shaped floor timbers were attached vertically, are identical to those left by the nails for the hull planking.

The sternpost knee has two carved recesses in its port side. The upper one is roughly triangular, measuring about 5 to 5,5 cm across and 2 cm in depth. The second recess has a foliate shape is 14 cm below the first and has exactly the same orientation (Fig. 6*a*). Also 2 cm deep, the recess is about 8 cm long fore-and-aft and 4 cm wide. This second cavity served as a countersink for an iron spike that penetrated the sternpost knee obliquely, yet traversed the fayed, inclined surfaces of the knee and the heel at a right angle (Fig. 11). The first recess does not contain any evidence of nailing and apparently represents an initial error in situating the countersink at its appropriate location.

The floor timbers

The Y-shaped floor timbers, typical of a ship's rising and narrowing at the stern, are represented in the case of the Corpo Santo by three preserved examples (01, 02 and 03), all in a poor state of preservation (Fig. 12).

TABLE I

Dimensions of the three Y-shaped floor timbers (in cm)

Dimensions / floor timbers Nr	01	02	03
Preserved height	107	118	121
Height to the bottom of the first futtock	85	89	85
Preserved overlap of the first futtock	36 (at a ht. of 94)	38,5 (at a ht. of 89)	42 (at a ht. of 95)
Moulded (transversal) section at the base	12,5	14	14,5
Sided (fore-and-aft)room at the base	15,5	16	10 (broken)
Moulded (transversal) section of futtock BB	impossible to measure	non-existent	impossible to measure
Sided (fore-and-aft)room of futtock BB	15,5	non-existent	impossible to measure
Moulded (transversal) section of futtock EB	impossible to measure	12	17
Sided (fore-and-aft)room of futtock EB	15,5	16	14

The space between Y-frames 00 (not preserved, but whose impression remained on the inboard face of the planking) and 01 is 15 cm, between 01 and 02 is 16 cm and between 02 and 03 is 16 to 16,5 cm.

Analogously, the horizontal distance between treenails that attached the hull planking to Y- frames 01 and 02 varies from 24 to 28 cm, and between 02 and 03, from 30 to 32 cm. This is evidence of a gradual increase in the interval between Y-frames in relationship to the sternpost.

Of the three preserved Y-shaped floor timbers, the lower part resting upon the sternpost knee is preserved only in P3. Here can be observed that the lower surface, in order to seat it upon the sternpost knee, is cut at an angle corresponding to the upper face of knee so that the floor timber remains vertical. A slight fore-and-aft groove may likewise be observed on the forward edge of this peak floor timber, evidence of a limber hole for the drainage of water along the sternpost knee similar to that observed on the aftermost Y-frames of the Ria de Aveiro A shipwreck. Also on this forward face, at 11 cm above the base and slightly off centre to the port, there is a countersink 4,5 cm wide and 2 cm deep, intended for a nail that passed from the Y-shaped floor timber down into the stern knee. Again, we note the similarity of this fastening with that found in the Ria de Aveiro A hull.

Finally, we may point out that the deadwood pedestals of the Corpo Santo Y-frames are notably longer than their equivalents on the Ria de Aveiro A ship. This characteristic seems to indicate a more pronounced rising at the stern, compared to the Ria de Aveiro A vessel. Such a form may indicate that the ship was intended for use on open water, compared to the flat bottom required for navigation in inland waterways.

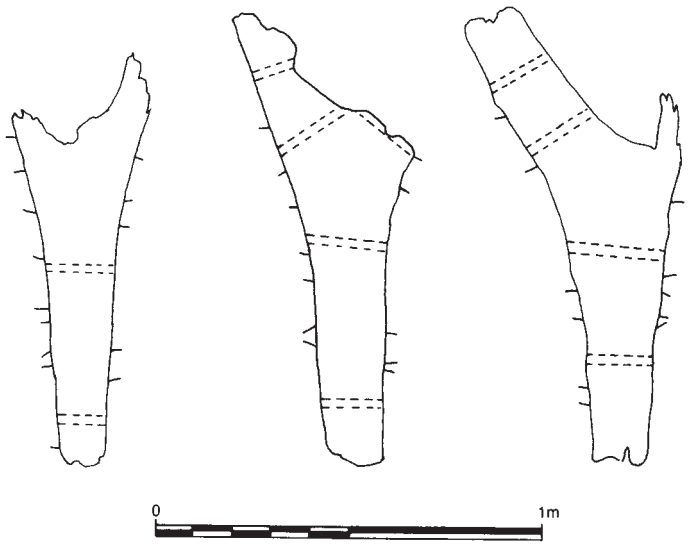

FIG. 12 – The Y-shaped floor timbers on the Corpo Santo shipwreck.

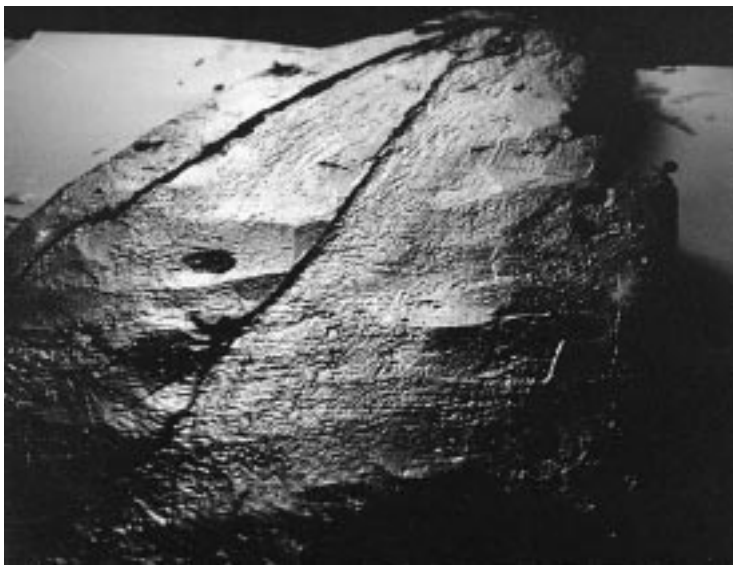

FIG. 13 – Carpentry tool marks on the Corpo Santo shipwreck. *Photo: P. Rodrigues.*

FIG. 14 – Saw marks on a surface of a plank from the Corpo Santo shipwreck. *Photo: P. Rodrigues.*

The outer hull planks

The thickness of the preserved outer hull planks, two on the port side and three on the starboard, is around 4 cm. In relation to other examples of ships of the Iberian-Atlantic tradition with similar dimensions, we note that this value is close or equal to that of the Highborn Cay (4,5 cm), slightly less than that of Ria de Aveiro A (5 cm), and greater than that of Western Ledge Reef (3,5 cm).

TABLE 2
Dimensions of the five planks (in cm)

Attributes / Plank	T1BB	T2BB	T3BB	T2EB	T3EB
Width	38	30	44	37	33
Preserved length	117	135	125	143	165

Observing the width of the port and starboard garboards, we note that their dimensions are greater than the second planks on each side. Nevertheless, the planking widths are asymmetrical but, due to the fragmentary preservation of the timbers, it is unclear whether this asymmetry may have been resolved at a specific strake.

All the preserved planks are bevelled on their outboard surface along the edge that is in contact with the heel. Thus, an edge is eliminated that otherwise would remain proud above the sides of the heel.

On the outboard face of starboard plank T2 is a channel 1,5 cm deep at its aft end where the gudgeon strap was inlaid, and is an extension of the gudgeon-strap channel on the upper part of the heel timber. Running 21 cm below the plank's upper edge, the channel is 13 cm long and 6 cm wide.

Finally, all the planks invariably exhibit the round marks of nail heads that lie within triangular countersinks, apparently made previously to receive the nail heads.

The planking fasteners

The hull planks are attached to the frames using a combination of roughly octagonal treenails that are 2,4 to 2,5 cm in diameter, and square-shanked iron nails measuring 1 cm to a side just below the head. The presence of the latter is indicated only by sandy-ferrous concretions and holes left in the wood. Judging from surrounding marks in the wood, the nails had round heads that were hammered in until flush with the surface of the plank.

At regular intervals along the planks, the treenails and iron nails are arranged along the axes corresponding to the Y-frames. At the hood ends, the fasteners are generally organised in two rows corresponding to the position of the sternpost knee and the heel timber, thereby strengthening the sternpost assembly. The treenails generally follow the curve formed by the lateral surfaces of the sternpost knee and the keel and sternpost rabbets. The same distribution may be observed for the iron nails which, on the sides for seating of the planks, are arranged in rows and are greater in number than the treenails.

From this distribution pattern, the reinforcing intention underlying the nailing of the planks is apparent. This intention is revealed by the alternation of treenails and iron nails and by their relatively close proximity to each other.

This mixed fastening pattern is similar to that found at Ria de Aveiro A and in other ships belonging to the Iberian-Atlantic tradition. However, treenails are not found in some larger ships built in this tradition, as noted at Cais do Sodré and in the presumed *Nossa Senhora das Mártires*, sunk at the mouth of the Tagus River in 1606 (Alves et al, 1998; Castro, 1998).

Wood identification

The identification of samples collected from different parts of the structure was done by Drs Wim van Leewaarden and Paula Fernanda Queiroz, of the Centro de Investigação em Paleoecologia Humana e Arqueociências of the Instituto Português de Arqueologia. It showed that all remaining pieces of the Corpo Santo ship are from Portuguese typical oak species:

- The heel is of *Quercus suber* L. (cork oak/*sobreiro*).
- The stern knee is of *Quercus rotundifolia* Lamarck (holm oak/*azinheira*).
- The peak floors 1 and 3 are of *Quercus suber* L. (cork oak/*sobreiro*) and the peak floor 2 is of *Quercus pyrenaica* Willd. (*carvalho-negral*).
- The five outer planks are of *Quercus suber* L. (cork oak/*sobreiro*).
- A treenail is of *Quercus suber* L. (cork oak/*sobreiro*).

Interestingly, this finding does not corroborate completely the classical sources of Portuguese naval architecture, specifically Fernando Oliveira (*O Livro* da Fabrica das Naos, c. 1580, ed. 1991, p. 64) and João Baptista Lavanha (*Livro Primeiro de Architectura Naval*, c. 1608--1616, ed. 1996, p. 27), who describe the use of cork oak for frames and pine for planking – combination that was only verified in the *Nossa Senhora dos Mártires* wreck, lost in 1606. Intriguingly, this archaeological evidence in the Corpo Santo wreck is the same as that of the mid-15*th* century shipwreck Ria de Aveiro A, whose planking, like the frames, are also of oak. Is this related with their earlier datation? Maybe yes. As we refer in this last case (p. 314) "*We may therefore suggest that, even though the pre-16th century Portuguese shipwrecks at Corpo Santo and Ria de Aveiro A represent a very small sample of the shipbuilding methods of their age, the oak structure of these wrecks illustrates the productive conditions of the pre-modern economy. Nevertheless, it is important to remember that Portuguese forest resources, and notably oak stands, were intensively exploited between the middle of the 15th century and the middle of the 16th century, a period that corresponds to the great age of Portuguese discovery and expansion and,* mutatis mutandis*, to an equivalent development in shipbuilding activity*".

Toolmarks

Planks T1BB, T2BB and T3EB show numerous, repeating toolmarks. These marks are in the form of a subtle, wavy scalloping. The individual concavities are about 5 cm in width and 5 to 6 cm long, and are only visible when viewed from a low angle when the surface of the wood is slightly moist (Fig. 13). Equivalent marks appear, for example, on the Gallo-Roman ships from Lake Neuchâtel made with a flat shipbuilder's adze or with a broad squaring axe (Arnold, 1992, p. 50, 53, 55), which illustrates the temporal durability of wooden shipbuilding techniques and the survival of specific types of tool. In other Iberian-Atlantic contexts, similar ship carpenter's adze marks have been noted on the *San Esteban* (Rosloff and Arnold, 1984, p. 294, 295).

Plank T3EB has similar scalloping on its aft hood end. However, this piece also has numerous parallel incisions across its width, observed along the planks entire length and corresponding to the movements of a saw (Fig. 14). Comparable saw marks were also noted on the ships from Lake Neuchâtel (Arnold, 1992, p. 42, 43).

Parallels

The closest parallel to the Corpo Santo ship, specifically with relation to the wood species used in its construction, the morphology of the heel and the thickness of the hull planking, is the Ria de Aveiro A shipwreck. Considering these similarities, it seems possible to suggest that the Corpo Santo ship, by analogy, may have been a typical coasting ship of the Atlantic coast of the Iberian Peninsula. However, due to the limited amount of evidence preserved, it is not possible to extrapolate its dimensions or tonnage[7].

Conclusions

In the context of the Atlantic region, the remains from Corpo Santo represent the oldest archaeological evidence of a ship built using the carvel-planked, skeleton-first principles and belonging to the Iberian-Atlantic shipbuilding tradition. The discovery of the ship is therefore a significant milestone in nautical archaeology.

Two other observations can be made. Firstly, Filgueiras (1988) observed that the first written evidence of skeleton-first construction in north-western Iberia dates to the 12th century, in the context of a Mediterranean technological transfer by Genoese or Pisan craftsmen. This observation must nonetheless be tempered, from the perspective of nautical history, by the many centuries of Arab maritime influence in the southern part of the Iberian Peninsula's Atlantic coast. The Arab culture was scientifically and technically very developed and the *Al-Andalus* and the African Maghreb were certainly not an exception. Despite its political and cultural coherence, this civilisation was exceptionally open to external influences, which must also have included the shipbuilding traditions that were evolving in the Mediterranean since the early Middle Ages. This presumption appears to be supported by the discovery of ship remains of presumed Arab origin in the western Mediterranean (Batéguier and Agay, near Nice), still under study but datable to the 11th century, which may already be characterised as corresponding to skeleton-first construction principles.

On the other hand, written sources indicate that it was only during the 15th century that the carvel planking technique spread from the Basque region to the coasts of Normandy and Flanders (Rieth, 1985). Documents describing this diffusion are, however, laconic as to the exact technical nature of this development. Therefore the wrecks of Corpo Santo and Ria de Aveiro A, the latter being contemporary with the diffusion of the carvel construction technique, constitute extremely valuable archaeological evidence.

Finally, we note that Corpo Santo is the earliest known example of the Iberian-Atlantic tradition having an axial rudder and a sternpost. However, this technology has been observed earlier in other construction traditions, as in the Zuyderzee NZ43 ship, excavated in 1971 in the Netherlands and dated to the late-13th or early-14th century (Steffy, 1994, p. 11), the cog of Bremen dated to 1380 (Steffy, 1994, p. 120) and, somewhat later, the wreck of the Almere Wijk, excavated in 1968 in the Netherlands and dated to 1422-1433 (Steffy, 1994, p. 121)[8]. These comparisons confirm the technological precociousness of the Ria de Aveiro A and Corpo Santo ships, which represent the recovery of one more missing link in the historical chain of European naval architecture and global technical history. At the close of the Middle Ages, the western Iberian Peninsula stands as a great centre for the synthesis of knowledge and experience that, at the beginning of the 15th century, would result in the construction of the Portuguese sailing ships of discovery (Alves, 1998c).

Some unfinished ship's timbers from the Ribeira das Naus shipyard, found in 1997 at Praça do Município

In September 1997, CNANS was asked by archaeologists from the city museum of Lisbon to examine several timbers recovered during excavations for an underground parking lot at the Praça do Município in Lisbon (Figs. 1 and 15). This work had been initiated by the city council without the prior approval of IPPAR, the Portuguese national heritage agency, as normally required for work conducted within a designated historical district. Interestingly, the riverbank location of these remains continues a line running east to west, defined by the Cais do Sodré and the Corpo Santo shipwrecks sites and corresponds to the well-known former location of the Ribeira das Naus shipyard (Fig. 16).

The timbers were clearly not part of a coherent shipwreck site, as the archaeological rescue excavation subsequently demonstrated.

In total, 11 significant pieces were recovered, either whole or in fragments, including some of impressive size (Figs. 17 and 18). With the exception of a keel segment bearing signs of previous utilisation (nail holes), all the pieces were framing timbers that had been roughly shaped as part of a typical stock of shipbuilding timbers.

As seen in the largest recovered piece, measuring 4,4 m long (Figs. 17 and 18, n. 3), the timbers were pre-cut according to the requirements of an architectural sequence. This was no doubt a common practice in shipyards but is nevertheless a rare archaeological find. A rare medieval parallel, from the 15th century, is a group of boat-building timbers, partly pre-fashioned, partly reused, discovered on the Poole waterfront (Hutchinson, 1994).

While their shape was suitable for use as floor timbers on several types of ships, the Praça do Município timbers provide an interesting comparison to the iconographic information found in one of the most important works of early 17th century Portuguese naval architecture, the *Livro de Traças de Carpintaria* by Manoel Fernandez (Fig. 19).

In conclusion, this discovery indicates that the riverside zones of historical harbours are, and should be treated as, the archives of our nautical heritage.

FIG. 15 – View of the site. *Photo: E. Riccardi.*

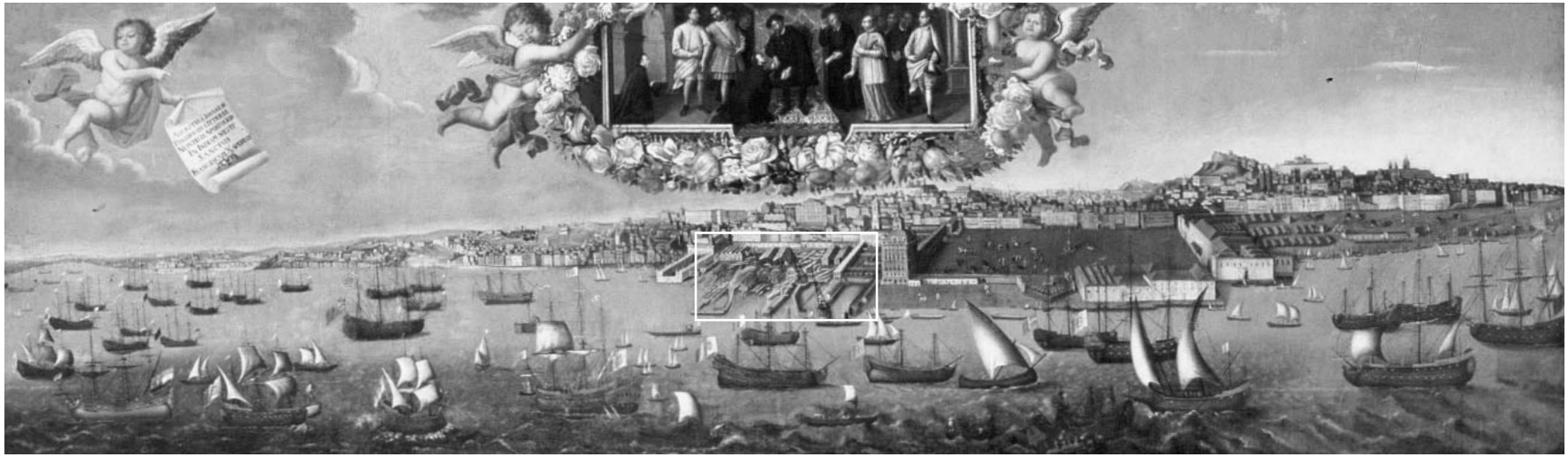

FIG. 16 – The Ribeira das Naus shipyard in a 17th century painting of the Museu Nacional de Arte Antiga.

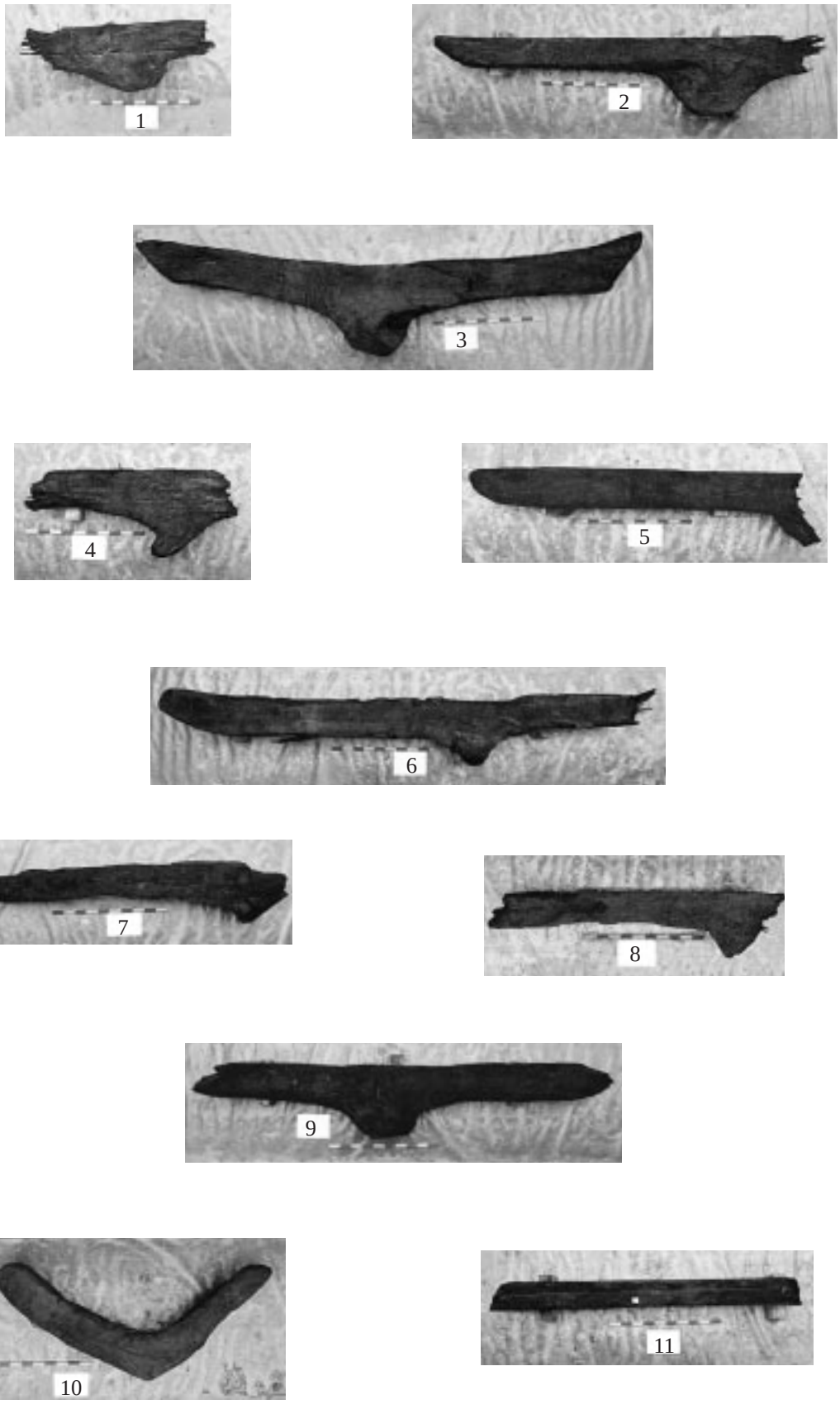

FIG. 17 – View of the whole pieces recovered at Praça do Município.

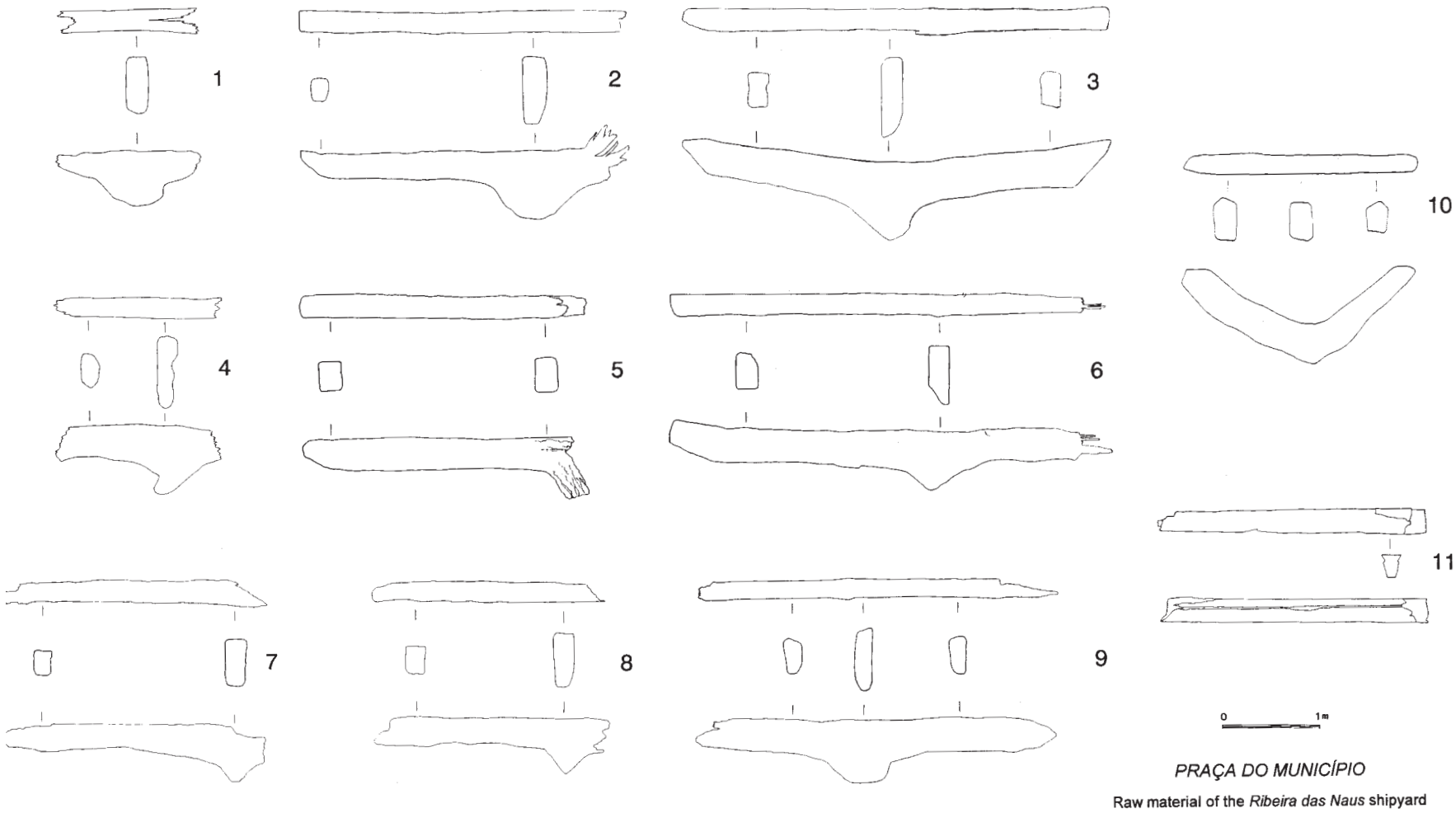

FIG. 18 – Drawings of the whole pieces recovered at Praça do Município.

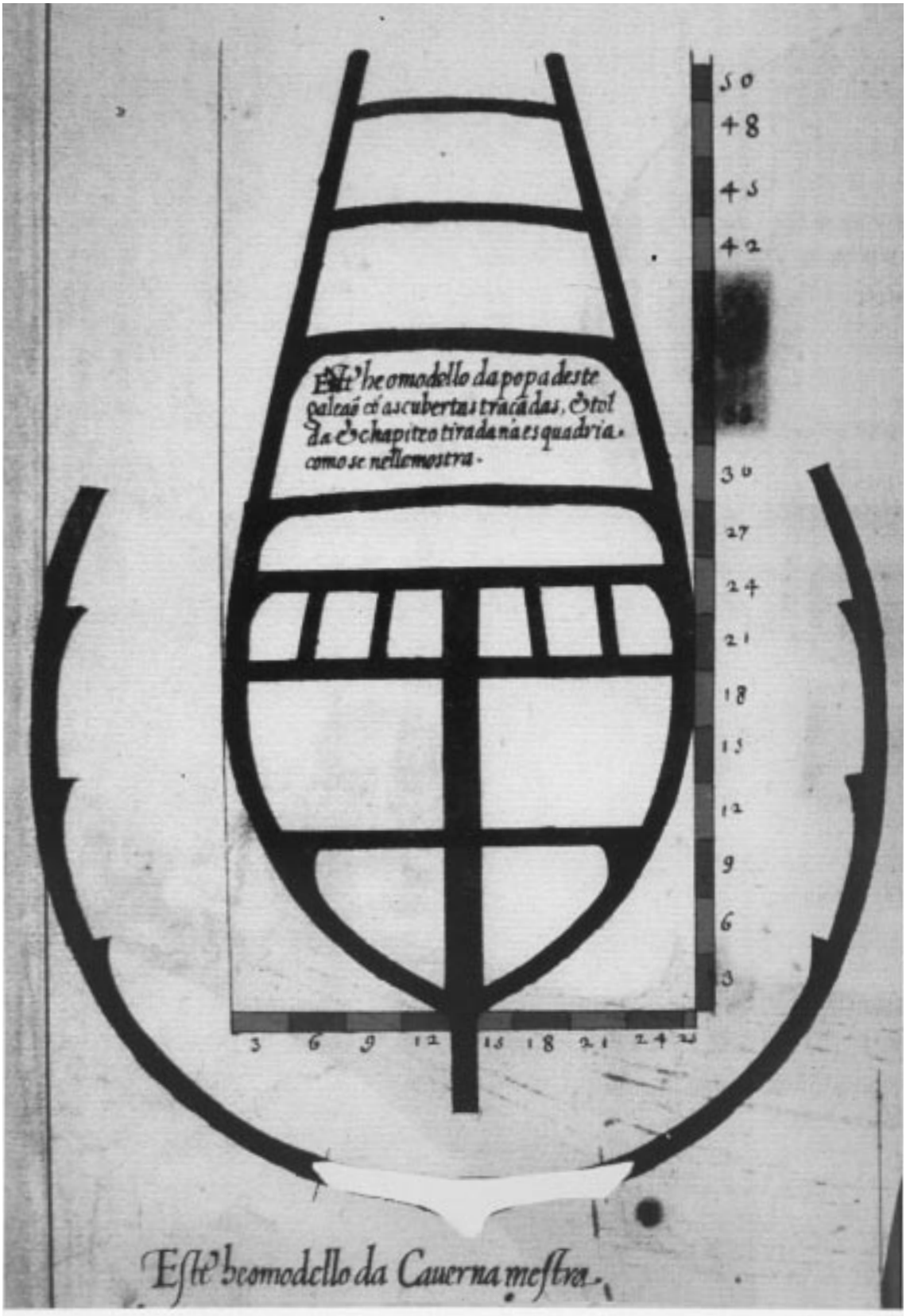

FIG. 19 – Comparison of a drawing of piece no. 3 with the iconography provided by one of the most important titles of the Portuguese naval architecture of the early 17th century, the *Livro de Traças de Carpintaria* of Manoel Fernandez (fl° 88v - a galleon of 500 tons).

NOTES

1 The discovery was made by a team from the Departamento de Arqueologia of the Instituto Português do Património Arquitectónico e Arqueológico (IPPAR) directed by the archaeologist Ana Vale. A preliminary paper about the discovery was published in 1998 (Alves, 1998b).

2 Laboratory ref.: Sac-1361. Dating was carried out by A. Monge Soares, at the Laboratório de Isótopos Ambientais do Instituto Tecnológico e Nuclear in Lisbon.

3 The preliminary salvaging of the ship was possible due to the effort of the archaeologist Ana Vale, whose subsequent collaboration is appreciated. She states in a personal note that: "*In the riverside area, from the end of the 15th century, a great landfill was made that was intended for the construction of the Royal Palace in the Terreiro do Paço and the workyards of King Manuel I next to the Porta da Oura (where the present Arsenal da Marinha is located. However, we calculate that the landfill below which the ship was found, although integrated in this movement for the conquest of land from the river, had been carried out later, linked to the work on the new Palácio dos Corte Real. The earth used in the construction of the landfill would have come from the demolition caused by the earthquakes of 1531 (whose destruction was as violent as that of 1755) or of 1551 (that killed two thousand persons in Lisbon). The Palácio dos Corte Real was constructed in 1585 (D. Cristóvão de Moura, 1585), and also is known as the Palácio do Corpo Santo and as the palace, or house, of the Marquis of Castelo Rodrigo.*"

4 In May 1997, with the restructuring of the services of the administration of the Cultural Heritage, the COAS created the Centro Nacional de Arqueologia Náutica e Subaquática (CNANS) within the scope of the Instituto Português de Arqueologia (IPA) (Decree-Law nr 117/97, March 14th). The study and preservation of the remains of the ship of Corpo Santo constituted one of the most important programmes of the C.O.A.S. The participation of Catarina Garcia, Ricardo Rodrigo, Carla Maricato, Paulo Pacheco, Maria da Conceição Silva and Armando Sousa in the dismantling work and in recording by drawing and photography of the remains of the Corpo Santo, as well as that of Pedro Gonçalves in their preservation are appreciated.

5 The disassembly was carried out without having to resort to special methods, such as those used to dismantle the hull of the *San Juan* (Waddell, 1986). The structure was maintained relatively intact, principally due to the action of the strong wooden framework. The pieces were easily separated, as the iron nails were totally oxidised and the planks of the covering slid easily along the existing wooden pegs. In the case of the Corpo Santo, this simple method of disassembly proved completely adequate, with no breakage of any of the material.

6 The oldest reference written in French about an *arcasse* stern dates to 1491. In *Nouveau Glossaire d'A. Jal. Révision de l'édition publiée en 1848. Letra A*, Paris La Haye, 1970, p. 36, definition of the term *arcasse*.

7 The preservation of a significant part of the hull of the Ria de Aveiro *A* allows us to calculate, using preliminary observations, that this is a ship with a keel about 8 *rumos* (12.32 m) long.

8 It should be noted that the use of a central rudder mounted on the sternpost had been introduced into Atlantic Europe at least by the end of the 12th century, as seen in a low relief of the baptismal font in the cathedral of Winchester dated to 1180, that is the oldest known iconographic illustration of this detail (Landström, 1961, p. 69).

BIBLIOGRAPHY

ALVES, F. (1998a) - Ria de Aveiro A - a mid-15th century shipwreck from the west-central Portuguese coast. In *Pre--Proceedings of the International Symposium on Archaeology of Medieval and Modern Ships of Iberian-Atlantic Tradition* (Lisbon, 1998). Lisboa: CNANS., p. 63-71.

ALVES, F. (1998b) - The remains of the Corpo Santo, a 14th century shipwreck and the remains of a shipyard at Praça do Município, Lisbon, Portugal. In *Pre-Proceedings of the International Symposium on Archaeology of Medieval and Modern Ships of Iberian-Atlantic Tradition* (Lisbon, 1998). Lisboa: CNANS, p. 88-91.

ALVES, F. (1998c) - Genealogy and archaeology of Portuguese ships at the dawning of the modern world. In *Nossa Senhora dos Mártires. The last Voyage: Catalogue* (Portuguese and Spanish version available). Lisboa: Pavilhão de Portugal / Expo'98; Ed. Verbo, p. 71-83.

ALVES, F.; CASTRO, F.; RODRIGUES, P.; GARCIA, C.; ALELUIA, M. (1998) - Archeology of a shipwreck. In *Nossa Senhora dos Mártires The last Voyage*. Catalogue (Portuguese and Spanish versions available). Lisboa: Pavilhão de Portugal / Expo'98; Ed. Verbo, p. 183-215.

ARNOLD, B. (1992) - Batellerie gallo-romaine sur le lac de Neuchatel. *Archéologie Neuchâteloise*. Neuchâtel. 12.1.

CASTRO, L. F. (1998) - The remains of a Portuguese Indiaman carrack at the mouth of the Tagus, Lisbon, Portugal (Nossa Senhora dos Mártires, 1606?). In *Pre-Proceedings of the International Symposium on Archaeology of Medieval and Modern Ships of Iberian-Atlantic Tradition (Lisbon, 1998)*. Lisboa: CNANS, p. 79-87.

FERNANDEZ, M. (1616/1989) - *Livro de Traças de Carpintaria*. Facsimile of the manuscript of the Palácio Nacional da Ajuda Library, MS n^{er} 52-XVI-21. Lisboa: Academia de Marinha.

FERNANDEZ, M. (1616/1995) - *Livro de Traças de Carpintaria*. Transcription and translation into English of the manuscript in the Biblioteca do Palácio Nacional da Ajuda, MS nr 52-XVI-21. Lisboa: Academia de Marinha.

FILGUEIRAS, O. L. (1988) - *Gelmirez and the reconversion of the W. peninsula shipbuilding tradition (XIth-XIIth centuries)*. In REINDERS, R.; PAUL, K., eds. - *Carvel construction technique*. Amsterdam (Oxbow Monograph; 12), p. 32-41.

GRENIER, R. (1988) - *Basque whalers in the New World: the Red Bay wrecks*. In BASS, George F., ed. - Ships and Shipwrecks of the Americas. London: Thames and Hudson, p. 69-84.

GUÉROUT, M.; RIETH, E.; GASSEND, J.-M. (1989) - Le navire Génois de Villefranche - un naufrage de 1516?. *Archaeonautica*. Paris. 9.

HUTCHINSON, G. B (1994) - The boat building timbers. In WATKINS, D. R., ed. - *The Foundry: excavations on Poole waterfront 1986-1987*: 23-42. Dorchester: Dorset Natural, History and Archaeological Society.

LAVANHA, J. B. (1608-1616/1996) - *Livro Primeiro de Architectura Naval*. Facsimile, transcription and translation in English of the manuscript of the Real Academia de la Historia of Madrid, Códice 63 of the Colecção Salazar. Lisboa: Academia de Marinha.

LANDSTRÖM, B. (1961) - *The Ship - O Navio*. Portuguese version. Lisboa : Publicações Europa-América.

L'HOUR, M. (1994) Construction navale. Un galion de fortune. In *Le San Diego - Un trésor sous la mer*. Catalogue of the exhibition - On a retrouvé le trésor du San Diego! (Grand Halle de la Villette, Paris, du 15 septembre 1994 au 8 janvier 1995). Paris : Ed. A.F.A.A./R.M.N, p. 118-157.

OERTLING, T. J. (1989a) - The Molasses Reef Wreck Hull Analysis: Final report. *International Journal of Nautical Archaeology and Underwater Exploration*. 18:3, p. 229-243.

OERTLING, T. J. (1989b) - The Highborn Cay Wreck: The 1986 Field Season. Hull structure analysis of the remains of possibly the two oldest European wrecks yet excavated in the Americas. *International Journal of Nautical Archaeology and Underwater Exploration*. 18:3, p. 244-253.

OERTLING, T. J. (1989c) - The few remaining clues. In ARNOLD III, J. B., ed. - *Underwater Archaeology Proceedings for the Society of Historical Archaeology Conference (Baltimore, 1989)*. Texas, p. 100-103.

OERTLING, T. J. (1998) - The concept of the Atlantic vessel. In *Pre-Proceedings of the International Symposium on Archaeology of Medieval and Modern Ships of Iberian-Atlantic Tradition (Lisbon, 1998)*. Lisboa: CNANS., p. 42-44.

OLIVEIRA, F. (1580/1991) - *O Livro da Fabrica das Naos*. Facsimile, transcription and translation in English of the manuscript of the Biblioteca Nacional of Lisbon, Códice 3702 of the Reservados. Lisbon: Academia de Marinha.

REDKNAP, M. (1984) - *The Cattewater Wreck. The investigation of an armed vessel of the early sixteenth century*. London (B.A.R.; 131).

RIETH, E. (1985) - La question de la construction navale à franc-bord au Ponant. *Neptunia*. Paris. 160, p. 8-21.

RODRIGUES, P. (1998) - Cais do Sodré B une épave de la 2ème moitié du XVème siècle/début du XVIème, à Lisbonne, Portugal. In *Pre-Proceedings of the International Symposium on Archaeology of Medieval and Modern Ships of Iberian-Atlantic Tradition* (Lisbon, 1998). Lisboa: CNANS., p. 72-79.

ROSLOFF, J.; ARNOLD III, J. B. (1984) - The keel of the San Esteban (1554): continued analysis. *International Journal of Nautical Archaeology and Underwater Exploration*. 13:4, p. 287-296.

SERRANO, J. L. R. (1991) - *Arquitectura de las Naos y Galeones de las Flotas de Indias*. Malaga: Ed. Seyer.

SOTO, J. L. C. (1988) - *Los Barcos Españoles del Siglo XVI y la Gran Armada de 1588*. Madrid: Ed. San Martin.

STEFFY, J. R. (1994) - *Wooden ship building and the interpretation of shipwrecks*. Texas, College Station: Texas A & M University Press.

TUCK, J. A.; GRENIER, R. (1985) - Discovery in Labrador: A 16th-Century Basque Whaling Port and Its Sunken Fleet. *National Geographic Magazine*. 168:1, p. 40-71.

WADDELL, P. J. A. (1986) - The disassembly of a 16th century galleon. *International Journal of Nautical Archaeology and Underwater Exploration*. 15:2, p. 137-148.

WATTS Jr., G. P. (1993) - The Western Ledge Reef wreck: a preliminary report on investigation of the remains of a 16th-century shipwreck in Bermuda. *International Journal of Nautical Archaeology and Underwater Exploration*. 22:2, p. 103-124.