SHIPBUILDING KNOWLEDGE AND HERITAGE

EDITORS
AMÉLIA POLÓNIA
FRANCISCO CONTENTE DOMINGUES

CITCEM
CENTRO DE INVESTIGAÇÃO TRANSDISCIPLINAR
CULTURA, ESPAÇO E MEMÓRIA

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TABLE OF CONTENTS

INDEX OF FIGURES

INDEX OF TABLES

INTRODUCTION

AMÉLIA POLÓNIA
FRANCISCO CONTENTE DOMINGUES

The history of humankind is inseparable from the understanding of the specific ways human societies connect with the sea. Since ancient times, the sea and the watercourses in general have been a means of obtaining food resources, especially for the riverside populations and, for the last five centuries, the main route for long-distance travel, transport and trade. In other words, since that time maritime routes have connected different global areas, boosting commercial, but also cultural and human exchanges, in a movement whose enormous importance led it to be known as the «opening of the world» (or other similar expressions). This «opening» was nothing more than a game of connections between continents, cultures, people, economic and scientific complexes, via the oceans. In the long term, the development of navigation techniques, naval architecture and naval industries were crucial factors to this equation. In our time, maritime transport is one of the most dynamic economic sectors, essential to the movement of large volumes of goods and of a growing number of travelers (increasingly synonymous with tourists — as seen in the huge development of the cruise industry) with lower costs and lower environmental impacts. From an economic point of view, *containerization* revolutionized a sector that, however, has faced advances and *substantial transformations* during the last five centuries, as studied by numerous specialists.

Shipbuilding became a strict prerequisite to these achievements, from the past to the present, and it forms the main focus of this book. This volume aims to put together, and into dialogue with each other, different approaches to this phenomenon, from the point of view of history, naval archaeology, heritage or even tourism — new areas that the 20th and the 21st centuries elected as crucial focal points of interest.

Historiographical tradition (national and international) seems to have been paying little attention to the possibilities of intersection between worlds apparently so diverse. Naval archaeology of small fishing ships or of those used in cabotage or river navigation frequently ends up in an ethnographic approach, and the study of transoceanic ships is self-centered, as if other vessels did not exist. Ship historians distinguish (unconsciously?) between the work of artisans and the work of engineers, without taking into account that the precariousness of the knowledge of the latter was for a long time closer to the first than it might seem, which is very much noticeable in the 16th and 17th centuries. In fact, we can only speak of shipbuilding engineers from the 18th century onwards, with one notable exception: the Portuguese João Baptista Lavanha (c. 1555-1624), author of *Livro primeiro de architectural naval*, written around 1600.

In recent historiography, Octávio Lixa Filgueiras (1922-1996), stands out as a leading figure in the international field of studies on traditional watercrafts. In a study of great scientific value and rigor, he showed how unfounded judgement can be if based more on *localisms* than on actual knowledge on the subject.

Once again, this book aims at overtaking this constraint, attempting a global, comparative and multifocal approach on shipbuilding, within the framework of a specific challenge that brought together experts in such diverse, however complementary, areas as maritime history, naval architecture, naval archeology, heritage and memory preservation.

This goes also for the project *Vila do Conde: um porto para o mundo (Vila do Conde: a Harbor to the World)*[1], that links the past with the future, as looking back helps to understand the conditions of some extinction processes and to enhance heritage preservation, when still possible. This is a community project which includes the recovery of spaces, techniques and social experiences associated with shipbuilding. It included, in an act of political intelligence, the unprecedent bid of having traditional wood-shipbuilding included in UNESCO'S Intangible Cultural Heritage list.

The project aims to gather the conditions for the survival of a technical knowledge in risk of extinction but also to start thinking the articulation of traditional techniques with those used in the building of ocean-going sailing ships such as the carrack or the galleon that crossed the seas of the world. Those articulations are only known, even if in very broad lines only, thanks to technical treatises elaborated during the 16th and 17th centuries.

[1] https://www.cm-viladoconde.pt/pages/771.

During the development of the project it became clear that multiple questions connected to practical problems posed by the work at the shipyards required clarification. These became clear along the reconstitution of a 16th century carrack (Urban Pilot Project *Viagem à Rosa dos Ventos*, now concluded, supported by European funds). The construction of this replica (the carrack *Vila do Conde*, nowadays) required contributions from the traditional crafts used in the production of sailing ships, putting in evidence the continuity of solutions from past to present, when facing similar technical problems.

The highest technological transformations occur closer to the large urban centers when compared to small towns, as in the case of Vila do Conde, where traditional knowledge persists. With a port and shipyard of secular tradition based on the construction of small ships, despite ups and downs across time, Vila do Conde became a place of choice for observing and recording this craft. This was largely due to the intelligent understanding of the cultural, material and immaterial importance of this unique and irreplaceable activity which faces a fatal threat in the (very) short future: the disappearance of the keepers of a technical knowledge remarkably complex and impenetrable to outsiders. Other artisanal activities face the same challenge, but shipbuilding differs due to its complexity and the persistent and extreme difficulty of ensuring its generational transmission.

In the context of this strategy and of the project previously mentioned, a group of experts on naval architecture and shipbuilding convened in Vila do Conde in May 2016. The results of their work were already published through the respective proceedings[2]. The overall aims of the International Congress were achieved: ships and traditional shipbuilding were studied under different perspectives, which were not devoted exclusively to anthropology or to the history of techniques. The proposed themes *Wood Shipbuilding — techniques and naval architecture; Social Memories and Community; Social uses of Memory, Heritage and Tourism* ensured a set of dynamic relations between past and present and its social uses.

After an exemplary work of preservation of historical memory, resulting in the reconstruction of the 16th century carrack, the recovery of the *Alfândega Régia* (the Customs House) and the Casa do Barco (the Boat House), Vila do Conde takes its place in the roadmap of congresses on this subject, with exceptional conditions and a favorable public policy framework, thanks to the investment made by its Town Council and Mayor, Dr. Elisa Ferraz.

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[2] POLÓNIA, Amélia; MIRANDA, Marta, *eds*. (2018) — *Construção Naval em Madeira. Arte, Técnica e Património. Atas do Congresso Internacional. 23-25 de maio/2016*. Vila do Conde: Câmara Municipal de Vila do Conde.

CITCEM — the University of Porto Transdisciplinary Research Centre Culture, Space and Memory has as one of its missions the study, preservation and dissemination of heritage. It therefore decided to follow up on this initiative, inviting some of the authors present at the congress, and other specialists, to submit texts that consubstantiate the goals previously set forth. This initiative fulfills another of CITCEM's strategies: the collaboration with local and regional entities, in particular those from the North of Portugal, generating a notable policy of transference of knowledge through initiatives developed in collaboration.

This book is the result of this partnership. It is divided into three parts: Part I deals with *Learning from Archaeology and Literature*; Part II focuses on *Business and Knowledge* and Part III debates issues related to *Shipbuilding Heritage and Social Awareness*.

Eric Rieth, Olivia Hulot and Marine Jaouen dedicate their attention to the wreck of a mid-17th century coaster from *Erquy-Les-Hôpitaux*. Discovered and assessed in 2002, the wreck is situated on the beach of the town of *Erquy-Les-Hôpitaux* (Côtes d'Armor, North Brittany). The vessel rescued is a coaster of less than 10 meters length, loaded with a cargo of limestone, whose construction can be dated by dendrochronology to the middle of the first half of the 17th century. This boat is seen as possessing a series of unusual architectural characteristics. Those, and notably the «floating» frames and the very heavy structure of the hull, raise questions about the principle and the methods of construction of this boat, perhaps originally from Southern Brittany. Besides the methodological problem of the role of the archaeological sources in relation to the written ones, the *Erquy-les-Hôpitaux* wreck raises the central question of its interpretation from the point of view of the history of naval architecture in the nautical region of the Eastern Atlantic seaboard, a meeting point of many ancient techniques from the Mediterranean and the North, with its own history of pre-Roman sea-going shipping.

Francisco Alves submits a revision of the archaeography of the preserved structures of *Ria de Aveiro A*, a mid-15th century Portuguese shipwreck. In this context, the author lists and analyses some historical, literary and iconographical references concerning the cog in relation with Portugal, taking as his starting point the article of Octávio Lixa Filgueiras *A nave esculpida numa torre da Sé do Porto* (1982), where the cog theme in relation with Portugal was evoked for the first time. Again, technical connections and longue durée approaches inform this contribution of one of Portugal's leading naval archaeologists.

António José do Carmo is an expert and practitioner of wooden shipbuilding in direct contact with Vila do Conde shipyards. Based on the building process of the ship Novo Rosa Clara, the last wooden vessel built in Portugal for inshore fishing, at the Samuel e Filhos Lda. Shipyard in Azurara, Vila do Conde, from April 2005 to July 2007, the author debates how the techniques used were based on project elements and the traditional techniques used in the mold loft. In doing so, the author brings to light an original analysis and technical projections of the oldest elements represented in drawings, dating from sometime between the turn of the 16th century and the dawn of the 17th century by focusing on naval literature from this period. This chapter aims at demonstrating not only how advanced shipbuilding was at that time period, but also at giving evidence that, at its core, this craft did not undergo any major changes during these last 400 years regarding wooden shipbuilding.

Within another layer, now dealing with *Business and Knowledge*, David Plouviez discusses public and private contributions in contracting French naval vessels in the 17th and 18th centuries. The author shows how the process of amassing a navy in the 17th century forced European states to collect substantial funds, build port infrastructure, organize supply networks and have a large and skilled labor force. As no power was able to take on the construction and maintenance of its war fleet by itself, outsourcing was frequent. The chapter contributions are evident, since in the French context this process remains quite unknown, while leading to a crucial flow of nautical knowledge and of workers between military and civilian seaports. The chapter contextualizes this phenomenon both at a European level and from the perspective of French naval policy, also considering the technical aspects and the stakeholders' performances.

Following the same path, but focusing on a different political territory, María Amparo López Arandia deals with *Timber Supplying in the South Spanish Dockyards During the 18th Century*. The author argues that the Bourbon takeover of the Spanish Crown 18th century meant a great deal for the development of naval industries. Different naval dockyards, such as Puntales or La Carraca, were established in the south of Spain, near Cádiz, which became a key location for the maritime trading during this century, after the move of the *Casa de Contratación* (House of Trade), from Seville to Cádiz in 1717. This led to the logistical and environmental implications dealt with in this chapter. The deforestation of areas located around these dockyards and the increased wood demand led managers of the maritime department of Cádiz to explore the possibilities of harvesting the forests of some inland areas, as those of Segura de la Sierra and its surrounding lands, located at the source of the River Guadalquivir. The pieces of wood from the forests of Segura were floated down the River Guadalquivir and received by the dockyards located in Cádiz, some months later. The focus of the chapter is, precisely on these complex processes of timber supplying for the naval construction.

On the following chapter, Richard Unger writes on *Portuguese shipbuilding & Low Countries practices*, by debating Iberian influences in the Dutch Golden Age. The author starts from the assumption that 16th century Portuguese and Dutch shipbuilders were known as the best in Europe and possibly the world. The products of their yards looked different and were mostly built for very different uses. Despite the obvious change in dominance in naval architecture and the divergence in practice, Unger hypothesizes that there were connections between shipbuilding in Iberia and the Low Countries. In both the learned and the practical traditions, Dutch writers and practitioners borrowed from their Portuguese counterparts. Evidence from the increasing body of archeological evidence generated in many parts of the world indicates similarities in shipbuilding methods and how Low Countries naval architects slowly and carefully shifted from traditional northern Europe ways to the superior designs from southern Europe — so the author states. Evidence from written works on shipbuilding which began to appear in the late 17th century in the Dutch Republic showed, according to this chapter, a similar borrowing from Iberia and then greater independence and novelty in both how ships were built and how shipbuilders thought about what they were doing.

The third section of the book — *Shipbuilding Heritage and Social Awareness* — puts together two main contributions. Filipe de Castro targets some crucial issues concerning politics and the Portuguese underwater cultural heritage. He states that most people care about the past, and understand its importance, but the cultural, economic, and strategic importance of the maritime cultural heritage is seldom clearly understood by politicians, journalists, intellectuals, and the general public. This chapter includes the debate on why, with a long seafaring tradition, Portugal has struggled so long with the study and preservation of its submerged cultural heritage in order to explain why, in spite of some efforts of both central and local authorities, the Portuguese submerged cultural heritage, in the country and abroad, is largely unknown worldwide.

Giving evidence of quite a different approach, based on an on-going project, Vladimir Martus presents the project to build and sail a magnificent replica of what is considered, in this chapter, as the most beautiful sailing clipper ship — the *Cutty Sark/Ferreira*. The chapter presents a practical example for how one can bring to life a floating heritage, explaining that the *Cutty Sark* will be built and sailed in a traditional way, as a living memorial to the Great Era of Sailing Ships, with the mission to promote sail as a way to empower shipping as an environmentally friendly alternative. By planning to use the exceptional knowledge in wooden shipbuilding, which still exists in Portugal, and bring in young volunteers, sharing with them the traditional skills, the project promises to perform as a vivid experience of replicating and promoting shipping and shipbuilding heritage.

The chapter explains that this requires rich experience in building replica-ships, and running large sailing vessels, which was achieved, in this instance, by building two replicas — the schooner *St. Peter*, and the sailing frigate *Shtandart* under the same project director, Vladimir Martus, mostly by using traditional tools and methods. Large teams of volunteers have taken part in those two shipbuilding projects. This contribution does not circumvent the difficult challenges to face: the *Cutty Sark 2* will have to meet modern safety standards without compromising the historic aspects of the original ship.

With this variety of contributions, combining the experience of scholars, underwater archaeologists, shipbuilding technicians and naval captains, this book will promote the concept of wooden shipbuilding as an important, and so far underestimated, factor of historical development. Now it is up to the political powers and a new generation of researchers to bring added value to the contents, the proposals and the testimonies of this collective book.

I

LEARNING FROM ARCHAEOLOGY AND LITERATURE

THE WRECK OF THE MID-17TH-CENTURY *ERQUY-LES-HÔPITAUX* (CÔTES D'ARMOR, FRANCE)

ERIC RIETH
OLIVIA HULOT
MARINE JAOUEN

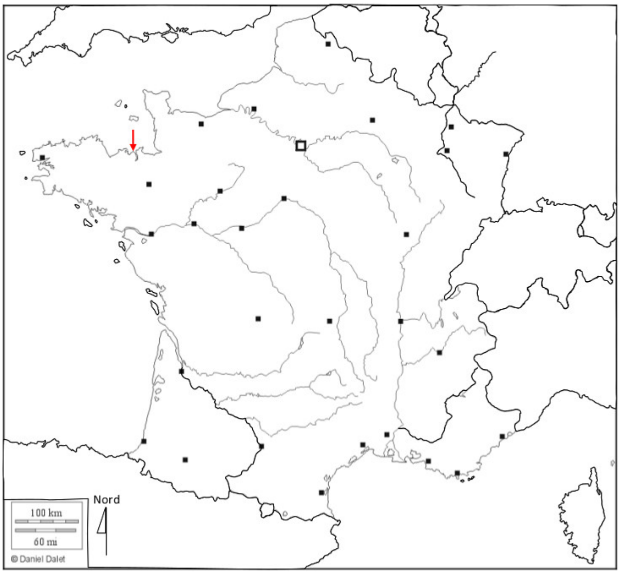

Fig. 1.1. Location of the wreck *Erquy-les-Hôpitaux*, Côtes d'Armor, France (all rights reserved) Source: Daniel Dalet

INTRODUCTION

The wreck at Erquy (Côtes d'Armor) was announced in 2002 by Yves Meslin and assessed in the same year by a team from Drassm (Département des Recherches Archéologiques Subaquatiques et Sous-Marines, ministère de la Culture) directed by Michel L'Hour and Elisabeth Veyrat. It is situated on the foreshore, alternately covered and uncovered by the rhythm of the tides (Fig. 1.1). In 2014 and 2015, the wreck was the subject of a programmed excavation carried out under the direction of Olivia Hulot and Marine Jaouen, archaeologists at DRASSM. The architectural study of the wreck was carried out by Eric Rieth (CNRS, LaMOP/Musée National de la Marine).

Besides, beyond the excavation, that operation is attached to a programme of multi-year studies directed by O. Hulot on the problems of excavation in the context of the foreshore which implies the definition of a strategy of terrain and the putting into effect of methods and techniques of excavation, as well as the recording of data (architectural statements in particular), adapted to such an «amphibious» environment (Fig. 1.2).

Fig. 1.2. General view of the site; the wreck is situated near the yellow tractor and the group of people
Source: Images Explorations — F. Osada

The cargo brought to light in the course of the assessment of the wreck was composed principally of a lading of lime in barrels and, perhaps as a complementary freight, a lading of slate.

The dendrochronological analysis of some 60 scantlings of wood has been carried out by Catherine Lavier (CNRS, Laboratoire d'archéologie moléculaire et structurale). The study of the oak staves of the barrels allowed two thirds of them to be dated to the 17th century, and to associate them geographically to the same ecological sectors of Burgundy. The analysis of the scantlings of the architectural remains, of elm, led to a dating of thirteen amongst them to the year 1627 (*post quem* date), in all probability very close to the felling date of the trees. In addition, these timbers present an ecological appearance corresponding more or less to that of the present «Pays de Loire».

The wreck was re-buried at the end of the 2015 campaign, using synthetic fabric, sandbags and sand.

1. WHY EXCAVATE THE *ERQUY* WRECK

The preliminary question that is posed is that of the scientific justification to excavate, with all the constraints and technical difficulties previously evoked, the wreck of a boat close to 9m long by about 3m breadth, whose construction is dated, in all probability, to the first third of the 17th century, and more precisely according to the results of the dendrochronological analysis, around 1627, close to the felling date of the trees. That interrogation returns, indeed, to a more general problem for the archaeology of wrecks of the modern era which, although clearly formulated in France during the 1980s[1] on the example of Anglo-Saxon research in particular, still seems to encounter sometimes certain difficulties in being accepted by our scientific community, despite the results obtained[2].

Why therefore excavate a wreck such as that at Erquy? The response hangs upon the weak knowledge of the history of naval architecture of this category of boat, which depends on a vernacular type of naval architecture. In the particular technical context of small private boatyards, it often appears difficult, for lack of sufficient sources, to describe, from the point of view of the history of techniques, the architecture of these boats of the modern era as one can do it summarily for that of the ships of Graeco-Roman antiquity, for which one can now define not only the principle and processes of construction, and their mutations over a long period of history, but equally, starting from the identification of «architectural signatures»[3] the evolution of the forms and structures of the hulls, or even the characteristics of different regional traditions.

Without going into detail, it is always important to recall briefly certain aspects in the body of that presentation, on the nature of the difficulties encountered in understanding through the written, graphic and iconographic sources of the modern era, the characteristics of the architecture of a boat such as that at Erquy. The first problem is connected to the mode of techno-economic production of the shipyards constructing these types of small vessels intended principally for coasting, short sea trades, and local fisheries. In this context of private and artisanal construction, the order for a boat was often given without relying on a plan or descriptive specification[4]. To take up the title of a book by the pre-historian André Leroi-Gourhan, vernacular naval architecture, to which the *Erquy* wreck belongs, relies above all, indeed, to a technical culture of «gesture and word», which leaves hardly any documentary traces for the historian of techniques

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[1] For one of the first articles in France, see RIETH, 1985: 7-11.

[2] For the results, see for example the issue of the review «Archéo-Théma», 2014, vol. 4, coordinated by E. Rieth and entirely dedicated to underwater archaeology of wrecks of the modern era in the Mediterranean. See also the volume of the Italian review «Archeologia Postmedievale», 2014, vol. 18, published under the direction of C. Beltrame and dedicated in its totality, as the subtitle «Archeologia dei relitti postmedievali» indicates, to the archaeology of post-mediaeval wrecks.

[3] That notion, defined at the outset, in relation to wrecks of the mediaeval and modern eras, is applicable to both ancient and contemporary wrecks (cf. RIETH, 1998: 177-188).

[4] The contracts for construction, when they exist, are reduced to the minimum, briefly mentioning the dimensions and financial conditions.

and archaeology to make use of, except the architectural vestiges themselves of the boat in question.

The second question concerns the technical sources, in the occurrence of treatises of naval architecture. It is necessary to await the 18th century for the appearance in these documents, be they manuscript or printed, of information of a technical order on the architecture of boats for coasting or coastal fisheries. As a general rule, it is principally the general characteristics of dimensions, proportions, forms of hull, or even rigging, that are mentioned. A revealing example of the nature of this data is provided by a manuscript entitled *Répertoire de construction*, dated 1752, by Pierre Morineau, the director of shipbuilding of the port and arsenal of Rochefort. This document describes, amongst other examples, a «Breton chaloupe, or chasse-marée […] serving for the transport for several purposes from the coast of Brittany to that of Aunis»[5]. These are principally the internal arrangements and proportions of that family of small sailing coasters, of lengths between 13 and 14.5m, whose hulls are in large part undecked for the smallest examples that are described. In addition, as a good royal constructor working in the arsenal and trained in a learned technical culture, where writing, calculation, geometry, drawing, thenceforth made part of professional training, Morineau drew up the transverse body plan, with diagonals (a usage not contemporary with the wreck), of the «Breton chaloupe» with a round stern. In summary, he provides no information on the actual structure of the vessel, that architectural «anatomy» according to the term of the historian A. Jal, excluding the characteristics of the longitudinal carpentry, the transverse carpentry, the planking, the methods of assembly of the different architectural elements… that in reality only the archaeological remains are susceptible to reveal, and which for the historian of techniques and archaeology constitute the fundamental data to define the principle and processes of construction.

The third problem that fully justifies the scientific choice to excavate a wreck such as that at Erquy is connected to the very great diversity and also complexity, in terms of known techniques, of vernacular naval architectures. In this respect, it seems necessary to briefly recall what the celebrated Swedish engineer-constructor Frederik Henrik af Chapman wrote in his treatise of naval architecture translated and published in French in 1781 under the control of Vial du Clairbois, an authority on the subject. Having identified two classes of ships «those which serve for coasting and short sea navigations […] and those which are employed in long-distance voyages and which are fit to navigate on the ocean», he follows by specifying his proposal:

[5] The manuscript treatise of MORINEAU, 2010: 212ff.

> *in examining the first class one sees vessels which different peoples use to serve for their transport in coasting or their commerce with their closest neighbours. But as the climates, the extent and the depths of the seas, the positions of countries in relation to the sea and between themselves, also their productions, are very different from one nation to another, the vessels cannot be of the same kind; they ought necessarily to be subject to these circumstances, as much in their proportion and form, as in the manner of their being rigged* […]. *If then one observes the vessels comprising the second class, one recognises that, constructed for the same end, they are, of whatever different nations, similar in their essential parts*[6].

In a very explicit, innovatory and pertinent manner, Chapman, as a practitioner of naval architecture, underlines the great diversity of boats for coasting, serving for small navigations, of which that from Erquy is a perfect illustration, which contrasts with a certain uniformity in the ships fitted for the long cours «proper to navigate on the ocean». That architectural diversity amongst coasters is applied not only at the scale of countries, but also, reduced, at that of regions, even of localities, referring to the environmental particularities of local and regional nautical spaces, to those of their functional techno-economic context participating in the construction of this archaeological concept of «Traditional zones of transport geography in relation to ship types», defined by the Swedish archaeologist Christer Westerdahl[7], which is translated into terms of the species of timber, dimensions, proportions, hull forms, types of structure, methods of propulsion, the nature of their use, methods of working…

It is with regard to these perspectives briefly recalled that the scientific objectives of the excavation and study of the *Erquy* wreck have been determined.

2. THE ARCHITECTURAL REMAINS: DESCRIPTION

2.1. Conservation of the Remains

The wreck, preserved at the outset over close to 9m length and 3m breadth, has been wholly exposed in two campaigns (2014 and 2015). The remains, preserved over only 7.8 by 2.6m after degradations (by clandestine activities) occurring since the assessment of 2002, present a strong transverse and longitudinal dissymmetry at the level of their preservation (Fig. 1.3).

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[6] CHAPMAN, 1788: IX-X.
[7] WESTERDAHL, 1995: 213-230.

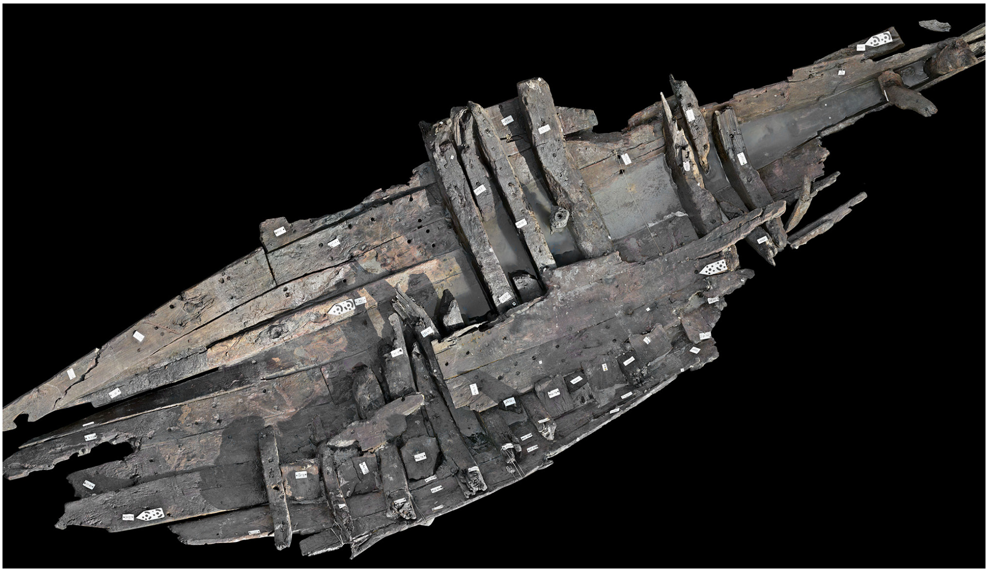

Fig. 1.3. Orthophotography of the wreck
Source: A. Guesdon

In a general way, the port half of the hull is better preserved in structure and form than the starboard half for the forward three quarters of the remains. The better preserved port side has six strakes preserved from the keel (VB13 to VB10), except in the last quarter aft where a single strake is preserved to port. On the starboard side, in large part broken except in its aft quarter where the hull has kept its form in elevation, only two strakes are preserved from the keel (VT15 and VT13) along the whole length and a third strake (VT20) is very partially preserved in the centre of the wreck. Of the frames, ten floor and crook timbers are preserved in total of which seven (VR57, VR58, VR59, VR61, VR62, VR63, IND82) are relatively good both in their form and structure. Three floor timbers are very partially preserved on their port ends (VR54, VR55, VR56). The greater part of the starboard futtocks have been destroyed. Only very short lengths of futtocks survive (MT51, MT52). In contrast, twelve futtocks are relatively well preserved to port (MB49-MB60). In the same way, no filling boards are preserved on the starboard side, while nine are present to port (AC10-18). No ceiling planks are preserved to starboard, while three ceiling planks remain connected to port, over variable lengths (Va11/Va22, Va12/Va32, Va23) (Fig. 1.4).

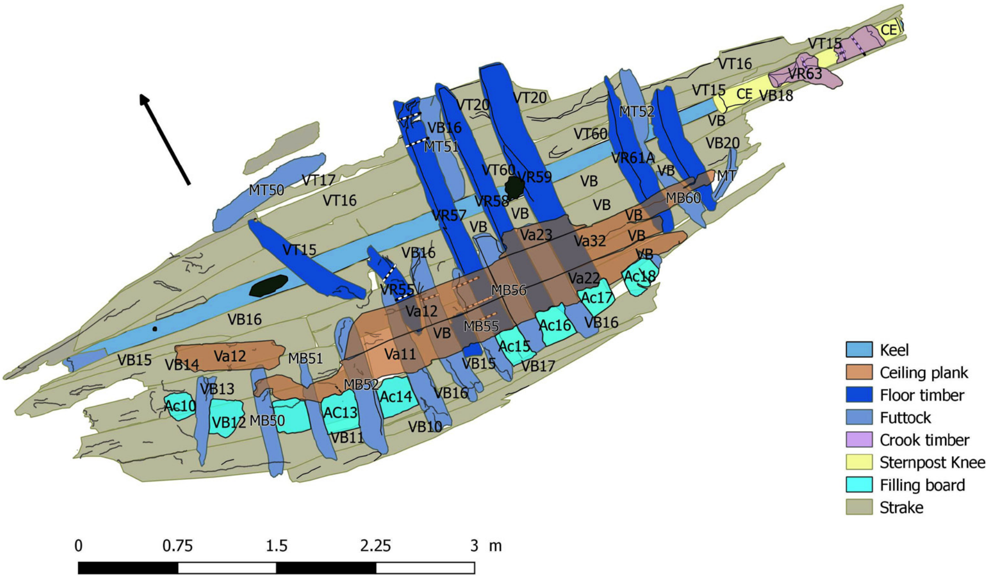

Fig. 1.4. Identification of the architectural elements
Source: Drassm

Forward, only the foot of the stem, or part of a foreknee is preserved, while no vestige of a sternpost remains at the stern.

2.2. The Longitudinal Carpentry

2.2.1. The Keel (Fig. 1.5)

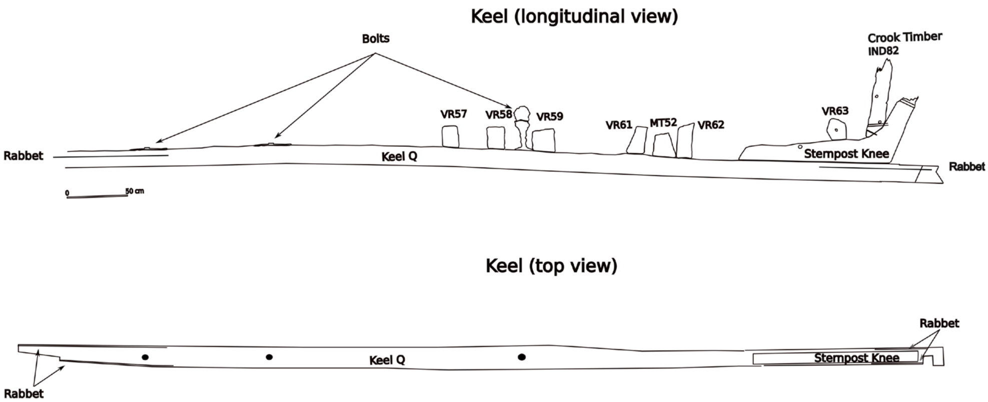

Fig. 1.5. The keel
Source: E. Rieth and E. Poletto

The keel, of beech[8], is wholly preserved in length. From the extremity of its scarf forward to the end of its skeg aft, its length is 7.1m. The longitudinal section taken off manually at the level of the back of the keel shows a regular curvature in the form of an arc whose offset height is between 7 and 8cm. This arc is confirmed in the longitudinal section created from the numeric photogrammetry of the wreck. The question arises as to the chronology of this curvature. In all likelihood, it is a deformation and a hogging of the extremities of the keel associated with the life of the boat, the most frequently attested case.

The average vertical height of the side of the keel is 11cm. At the scarf forward it is 14cm. At the skeg aft the height seems much reduced. It is 9.5cm. The breadth of the upper face, the only one that could be measured, evolved slightly along its length. It is 14cm at the fore extremity (not including the scarf), 16cm at the mortise for the stern-post, and 14cm at the skeg aft. Between the two extremities, its average breadth is 15cm.

The keel, starting from the extremity of the scarf forward, presents a particular shaping over a length of 1.4m. The arrises of the upper surface of the keel are in effect given a chamfer. At that level the breadth of the upper face of the keel is only 10cm, but below the hewn edges of the keel it is 14cm. The section of the keel then becomes rectangular over most of its length. It is possible that the chamfer forward may be intended for the garboard to be better fitted, which, logically, is set at this level as a function of the rapid and significant narrowing and rising of the entry and run of the hull.

Besides this chamfer forward, a second important characteristic has been observed. It concerns the rabbet which is limited to the two ends of the keel. At the bow, the rabbet begins at the level of the scarf intended for the assembly of the stem and ought presumably to be prolonged in the cheek of the stem. At the stern it commences at 17cm from the skeg and is extended on one part of the mortise for the foot of the stern-post. Its length cannot be precisely determined. Its width is 4cm. The positioning of the rabbet towards the fore and aft extremities of the keel is without doubt connected with the necessity of ensuring a better support to the garboard and to reinforce its fastening at

[8] In respect of the beech keel, there are two principle points to be made. In the first place, beech is considered today as a timber poorly adapted to shipbuilding, notably for the pieces which in tidal zones are susceptible to being as often dry, when the boat is beached at low tide, as in the water. If that characteristic of the beech of inferior durability and of a tendency to split and attack by worms can be applied to the case of the planking of the upper part of the live-works, it seems that it ought to be to a great extent discounted for the keel, the garboards, which even at low tide, rest in an essentially humid context in the mud or sand, and thus not submitted to that alternation of humidity and dryness. In the second place, the use of beech may sometimes appear to be considered as an «architectural signature» of Basque shipyards from the end of the Middle Ages to the beginning of the modern era. In reality it can stated as a fact in regard to the historic documentation, that shipyards in other territories than the Basque in the Atlantic-Channel arc have chosen to make their keels in beech. This is the case, notably, in the Normandy shipyards (Haute Normandie) in the second half of the 16th century, as the thesis by Anne Gérardot of the École des Chartes has perfectly demonstrated, based on the specifications for construction and repair of the ships fitted out for the Newfoundland fishery, and for commerce, which are preserved in the notarial archives of Rouen and Honfleur. One of the reasons for such a choice is very probably connected to the existence, in proximity to the shipyards of that part of Normandy, of forests of beech. The length and straightness of the trunks of the beech make them, in all probability, the preferred timber for making keels.

a place where the hull is closed up, as it approaches the sternpost particularly, requiring a significant twisting of the planking with, as a consequence, strong mechanical restraints.

The forward extremity of the keel is provided with a plain vertical scarf 26cm long intended for assembly with the foot of the stem. The oblique scarf of classic morphology has a breadth of 7.5cm at its rear end and 4.5cm at its front end. Its height is 14cm.

The aft extremity of the keel is given a mortise open on its port side into which the foot of the sternpost is assembled (Fig. 1.6). This building of the tenon of the sternpost into an open mortise appears to be uncommon with regard to the usage of a closed mortise which is itself attested in Western and Northern Europe from the end of the Middle Ages. The mortise has a breadth of 9cm, a length of 12cm, and a depth of 9.5cm corresponding to the height of the keel at that point. These dimensions evidently correspond as well to those of the tenon of the foot of the sternpost. The aft face of the mortise is fashioned obliquely. The inclination in relation to the upper horizontal face of the keel is of the order of 70 degrees, a value which, as we will examine later, corresponds to that of the aft face of the sternpost knee and therefore of the sternpost. That of the forward face has not been observed. Besides the open mortise, the aft extremity of the keel possesses two other characteristics. The first is a discontinuity of 0.5cm between the height of the keel (9cm) at the level of the notch and that of the keel forward of the notch (9.5cm). The second is a skeg of angular profile, of 7.5cm length.

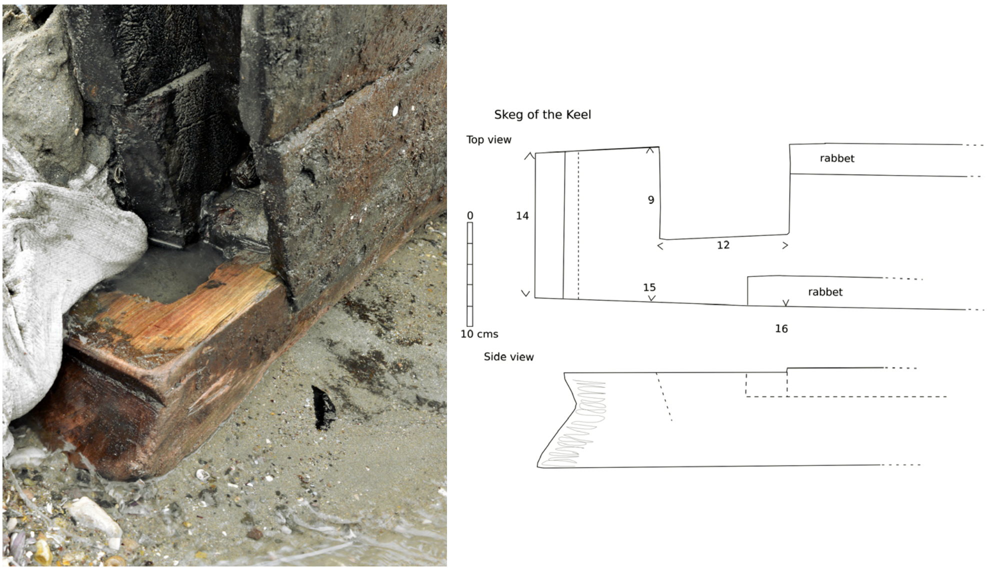

Fig. 1.6. The open mortise in the aft extremity of the keel
Source: Images Explorations — F. Osada; E. Rieth/S. Bertoliatti

One last characteristic of the keel, very important from the point of view of the general knowledge of the interior carpentry of the hull, has been registered. Along the whole length of the upper face of the keel, just three traces of assembly by an iron pin have been observed (Fig. 1.7). The first, corresponding to a pin of 3cm diameter, is situated at 70cm from the forward extremity of the keel, some 1/10 of the length of the keel. The second, corresponding to a pin of 4cm section, is placed at 1.66m from the forward extremity of the keel, or around 1/4.3 aft. Finally, the third is placed at 3.8m from the forward extremity of the keel, or around 1/1.9 aft. Unlike the other two this pin of 3cm section is preserved intact in height under the form of an iron concretion. Its height is 37.5cm. This pin is located in the space separating the floor timbers VR48 and VR59. An important characteristic to recall: these three pins are the only traces of the assembly observed, and carefully checked on various occasions, on the upper face of the keel. They are essentially intended to fix a keelson — not preserved — to the keel. That signifies that the floor timbers, with the exception of the rising floor timber VR61 fixed to the keel by two carvel nails, are «floating», that is to say without any assemblage, in relation to the keel. We will return during the study of the framing to the floating character of the floor timbers.

Fig. 1.7. Three traces of assembly by iron pins/bolts in the keel
Source: Images Explorations — F. Osada

2.2.2. The Stem, or the Foreknee

The only piece of the longitudinal carpentry actually identified as oak, the stem is preserved over a total length of 40cm, although during the assessment carried out in 2002, the stem, without doubt having a certain curvature and with a marked appearance of rake[9], appeared relatively well preserved in elevation. There is no doubt, then, on its identification. This is not the case for the piece observed in 2014 at the forward extremity of the keel, whose form, position and state of preservation (degradation uniquely on its forward extremity, notably) could correspond either to the beginning of the stem, or to the after part of the foreknee, to be assembled in the vertical plain scarf cut in the keel, and being fixed by means of a nail driven transversely from the exterior vertical face of the piece. In the case of the hypothesis of a foreknee, the foot of the stem, not preserved, would in turn come to be assembled by a scarf to this presumed foreknee and to the keel. In addition, the placing of a treenail has been identified on the right upper face of this extremity (stem or foreknee), which otherwise presents numerous traces of a pitch--based coating. The blind hole for this treenail ought in all likelihood to correspond to a point for assembly of a piece of internal reinforcement, perhaps an apron.

2.2.3. The Sternpost Knee

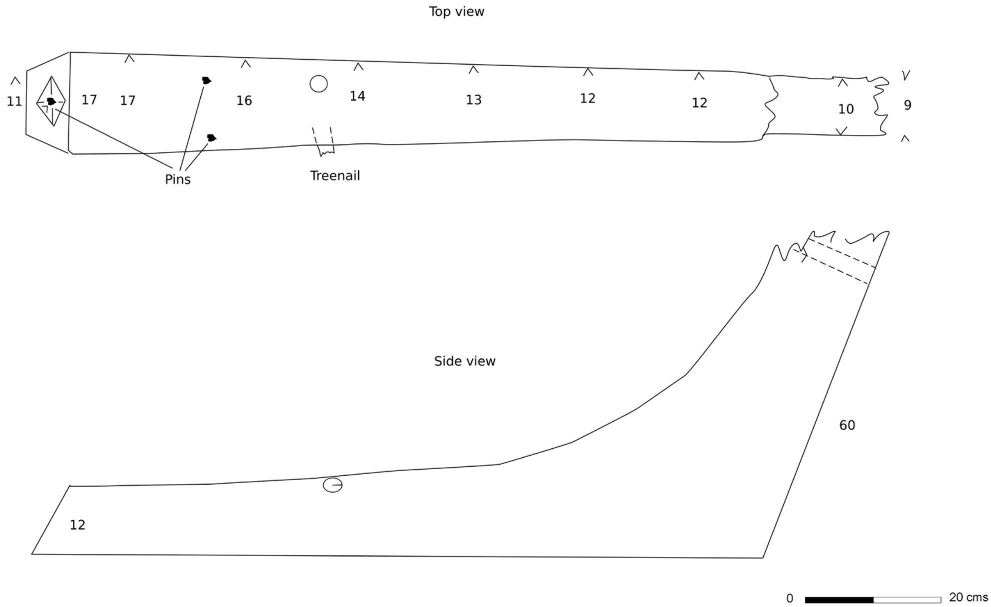

Fig. 1.8. The sternpost knee
Source: S. Bertoliatti

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[9] A slight forward rotation of the stem accentuating the effect of the rake is not to discount it totally.

The sternpost knee CE, of unidentified material, preserved over its full length and partially in height, was in position, in connection with the keel and the port and starboard planking. Its length on the lower face of its horizontal arm is 1.3m, its height at its forward end is 12cm, and 60cm on its vertical arm, the breadth of its upper face reduced progressively from 17cm at its front end to 12cm at its rear end. The breadth of its vertical face, regularly fashioned and in contact at its end originally with the sternpost, is 10cm in its upper part and 9cm at its base. This strong piece cut from a natural knee appears, paradoxically, weakly assembled to the keel. At its front end, one square iron carvel nail driven through a pilot hole ensures its initial assembly. At its upper face, two iron concretions have been observed at 26cm from the front end of the horizontal arm of the knee. It seems likely that these two spikes were intended to assemble the foot of a crook timber rather than to fix the sternpost knee to the keel. At 44.5cm from the front end, a treenail of 3cm section, whose position seems to be displaced towards the starboard arris of the knee, seems to correspond to a second point for assembly of the knee to the keel. It is however necessary to emphasise that in that part of the wreck it was very difficult to fully drain the water accumulated between the sides. From this fact, and despite the controls, another point of assembly could have escaped our observations. Two other treenails have been identified. The first is situated at 44.5cm from the forward end of the horizontal arm of the sternpost knee in its port lateral vertical face. This treenail of 3cm diameter fixes the port garboard to the knee. The second blind treenail is located in the aft face of the knee, at 48cm from its base. This treenail of 3cm diameter made the initial fixing of the sternpost to its knee.

2.2.4. The Sternpost

A first «phantom piece»: although totally destroyed, without doubt recently by clandestine activities as was also the case for the stem, several characteristics of the sternpost can be reconstructed such as its section, its rake and the position of the rabbet. The breadth of the end of the keel at the position of the open mortise into which the tenon fitted allows us to reconstruct that of the sternpost: 16cm at its front face and 15cm at the aft face. We note that the tenon, instead of being centred as customarily, was offset in the port half of the sternpost, the other half of the foot of the sternpost being supported to starboard on the upper face of the keel. The breadth of the vertical face can be determined as a function of the position on the keel of the aft face of the sternpost knee on the one hand, and on the other from the apparent breadth (around 12.5cm) of the starboard face of the sternpost deduced from the photos taken during the assessment of 2002. In terms of this data the breadth can be estimated as around 21cm. One other characteristic of the sternpost can be specified: a rabbet of length 8.5cm (photographed in 2002) was cut in the vertical face of the sternpost.

2.2.5. The Keelson

A second «phantom piece»: the keelson[10]. A bolt, that situated between the floor timbers VR58 and VR59, is preserved intact to its head (Fig. 1.9.). Its height is 37.5cm. Taking account of the height of the two floor timbers (17 and 19cm), the height of the keelson can be reconstructed in all likelihood as around 18cm/18.5cm above the floor timbers. No data allows its breadth to be reconstructed. As a hypothesis, a breadth close to that of its height seems reasonable. The length of the keelson is more difficult to determine. Its minimum length in terms of the three points of attachment could comprise between 3.8 and 4m. As to its maximum length it seems hardly possible to evaluate it, from the too great number of unknowns. Two characteristics however are certain. On the one hand, the reconstructed section of the keelson appears clearly to be stronger than that of the keel and consequently makes the keelson into a major piece of reinforcement of the primary longitudinal carpentry of the hull, even if the number of bolts in the assembly and their intervals appear a little too reduced in relation to the reconstructed length of the keelson. It is besides possible that that presumed keelson, in a principal or secondary role, served as a mast step. If the relationship of proportions between the sections of the keelson and that of the keel corresponds to traditional practices[11], the weakness of their assembly seems unusual, and in any case reduces the structural function of the keelson. On the other hand, the three bolts are located, for one amongst them for sure and for the others in all probability[12], in the space separating two floor timbers. Although it hardly conforms to the theoretical usages that wish the bolts to pass systematically through a full thickness over their whole length at the risk of weakening their solidity, the *Erquy* wreck shows, after other wrecks, that important deviations can exist between the theoretical precepts of the treatises and the practical reality of the shipyards.

[10] In 2014, one displaced piece (Ca) situated in the fore part of the wreck had been identified as perhaps corresponding to a part of the keelson. This fragment is of elm and the seven associated treenails are oak. It would seem that that identification ought to be considered with great reserve. No trace of assembly by means of treenails has been identified on the back of the keel. The question remains for the floor timbers of the fore part of the wreck, of which none is preserved.
[11] Cf. for example the keelson /mast-step of the boat of Lanvéoc (model in the Musée National de Marine, Inv. N.º 3 CP 5. This model had been made from data from 1830, published by PÂRIS, 1882: vol. 1, 38. As we will examine it later, this sailing cargo vessel represents a preferential model for comparison with the *Erquy* wreck.
[12] Because of the absence of preservation of the floor timbers.

Fig. 1.9. The best preserved iron pin/bolt between the floor timbers VR58 and VR59
Source: Images Explorations — F. Osada

2.3. The Transverse Carpentry

2.3.1. The Frames (Fig. 1.10)

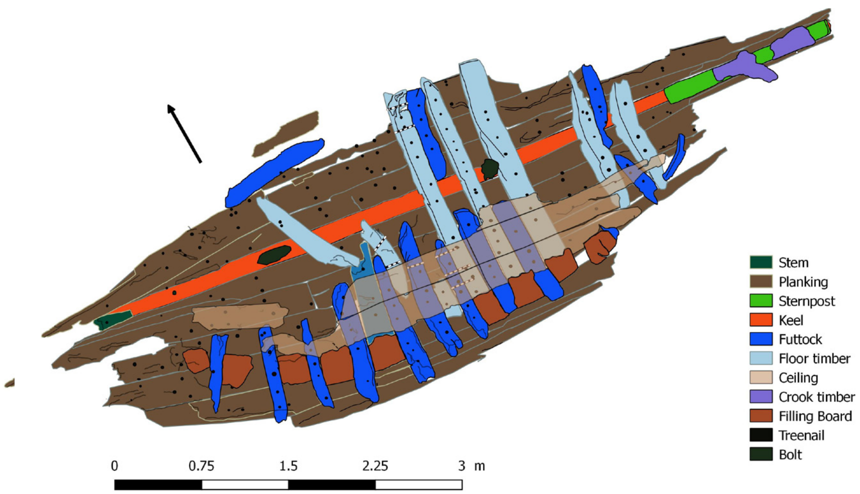

Fig. 1.10. Planimetric view of the architectural remains
Source: Drassm

In total, these are ten floor timbers and crook timbers, which are preserved, of which seven (VR57, VR58, VR59, VR61, VR62, VR63, IND82) are relatively good, both in their form and their structure. The last frames forward have completely disappeared. To port, three floor timbers are very partially preserved, and displaced, too, at their port arms (VR54, VR55, VR56), the only ones preserved. The greater part of the starboard futtocks have been destroyed. Only very partial lengths of futtocks exist, MT51 and MT52. To port, in contrast, twelve futtocks are relatively well preserved (MB49, MB50, MB51, MB52, MB53, MB54, MB55, MB56, MB57, MB58, MB59, MB60) of which two MB50 and to a lesser extent MB49, were displaced. Despite this partial state of preservation of the frames, numerous important observations for the knowledge of the transverse carpentry have been made.

On the scheme of the general disposition of the transverse carpentry, four principal characteristics have been brought to light. Firstly, the two first futtocks to port, MB49 and MB50, and even perhaps the third MB51, seem to present a certain inclination in relation to the other futtocks, which are disposed following an axis perpendicular to the keel. Secondly, all the preserved futtocks are systematically overlapped without connection, against the front vertical face of the floor timbers in regard to the stem. Now, the disposition considered as traditional, even canonic, according to theoretical precepts of carvel shipbuilding on the transverse principle, «frame-first», is the inverse of that of the *Erquy* wreck. According to that traditional disposition, the floor timbers of the wreck ought to be situated in direct regard to the master section, which constitutes a transverse axis of symmetry. Forward of that, the futtocks ought to be crossed on the front face of the floor timbers. Aft of the master section the futtocks ought to be fixed on the rear face of the floor timbers with respect to the stem. Thirdly, the lower end of the futtocks are worked obliquely, making the general organisation appear to rest on criteria other than that considered as traditional. It can be said, indeed, that the lower extremities of the port futtocks MB52, MB53, MB54, MB55 are cut obliquely and that the tapered lower extremities are oriented toward the stem.

Conversely, the obliquely worked lower extremities of the port futtocks MB56, MB57, MB59 and MB60 and those of the starboard futtocks MT51 and MB52 have their tapered extremities oriented towards the sternpost (Fig. 1.11). If one takes into account that orientation of the lower extremities of the futtocks as a criterion for the organisation of the frames, the master section could be situated at the frames VR57/MB55, confirming the transition with the frames of the after part of the hull, for which the direction of the bevel of the lower extremity of the futtocks is reversed. We add that that frame VR57/MB55 is situated at around 35 cm forward of the middle of the length of the keel, a position completely compatible with that of the master section. Lastly it will be seen that this frame, presumed to be the master section, possesses besides another very important characteristic.

Fig. 1.11. Obliquely worked lower extremities of the futtocks; the direction of the bevel is reversed
Source: Images Explorations — F. Osada

The fourth and final characteristic: no trace of any treenail has been observed on the interior face of the side between the upper extremities of the futtocks. That absence of any indication of the assembly tends to indicate that no second level of futtocks existed, and that the extremities of the futtocks directly associated with the floor timbers were extended to the full height of the hull. In that configuration, each frame was thus composed of one floor timber and two futtocks, one to starboard and one to port.

We examined previously the question of the dimensions of the frames and their spaces. These are relatively irregular. The average breadth on the upper face of the floor timbers is 14.3cm, with a minimum of 13cm (VR57) and a maximum (VR59) of 18cm. The average breadth of the upper faces of the futtocks is 13cm for a minimum of 9cm (MB51) and a maximum of 18.5cm (MB52). At the level of the filling boards, the average moulded thickness on the vertical faces of the futtocks is 15cm. These scantlings of the frames, other than that of the very heavy floor timber VR59 to which we will return, appear relatively significant in relation to the length of the keel bearing on the ground (7.1m) which represents one of the basic references for the dimensional definition of a boat. The measure of the spaces between the floor timbers is less meaningful because of the dispersion of the measures.

The impression that is drawn is that of a relatively dense disposition of frames. To evaluate that density, a coefficient for comparison is that provided by the ratio between the sided breadth of the floor timbers and the distance between centres of the floor timbers. The smaller the coefficient, the less the density of framing is. In the case of the *Erquy* wreck, the coefficient is round 0.45 (the maximum possible is 0.5: the room equals the space) corresponding to dense framing. In summary, in the case of the «*Lanvéoc* boat», still called the «gabare of Brest roads», for which data was taken in 1830, shows a small sailing transport vessel able to serve as a model for comparison with the *Erquy boat*[13], the coefficient is of the order 0.17, corresponding to a low density of framing. Now it is interesting to note that the *Lanvéoc* boat, of a size comparable to that of *Erquy*, and of which the scantlings of the frames are slightly more reduced than that of *Erquy* (12.2cm sided breadth of the floor timbers), is qualified by Admiral Pâris as «a kind of boa […] heavily constructed, in heavy pieces, spaced out and poorly fitted… It was reputed for its security, but not for its speed […]». With regard to this commentary on this «heaviness of construction» of the *Lanvéoc* boat, it would seem that the *Erquy* boat ought to relate to a still heavier form of construction, which will be evaluated from hydrostatic calculations made within the body of the researches to come on the reconstruction of the forms of the hull. Concerning the other characterisics of the *Lanvéoc* boat emphasised by Pâris, frames spaced out and poorly fitted, they do not apply, in summary, to the *Erquy* wreck.

We are considering at present the question of the relationships between the floor timbers and the futtocks on the one hand, and between the floor timbers and the keel on the other. With the exception of two frames, the floor timbers VR56 and VR57 and the futtocks MB55 and MB54 the others are characterised by a simple overlap, with sometimes a separation of some centimetres, between the floor timbers and futtocks (Fig. 1.12). The floor timber VR57 is itself overlapped with the MB55. At the level of the port futtock, three treenails of 3cm average section driven horizontally from the front vertical face of the futtock, connecting it to the floor timber. A nail, driven from that same face and situated at the lower end of the futtock, probably served to ensure a temporary connection before boring and treenailing. At the starboard floor timber VR57, whose end is eroded, two treenails and a nail having the same connecting function are preserved. An overlap and a similar connection between the floor timber and futtock are found at floor timber VR 56 very partially preserved, and its futtock MB54. A nail at the end of the futtock and two treenails disposed at 42 cm centres ensuring the connection. These two frames are the only ones to have the floor timbers and futtocks connected. All the other frames have futtocks floating in relation to the floor timbers. It is evident that that these very particular characteristics of the frames of the *Erquy* boat have consequences, which

[13] PÂRIS, 1882: vol. 1, 38.

we will consider in the third part of the study, at the dual perspective of the principle of construction and of the method of construction.

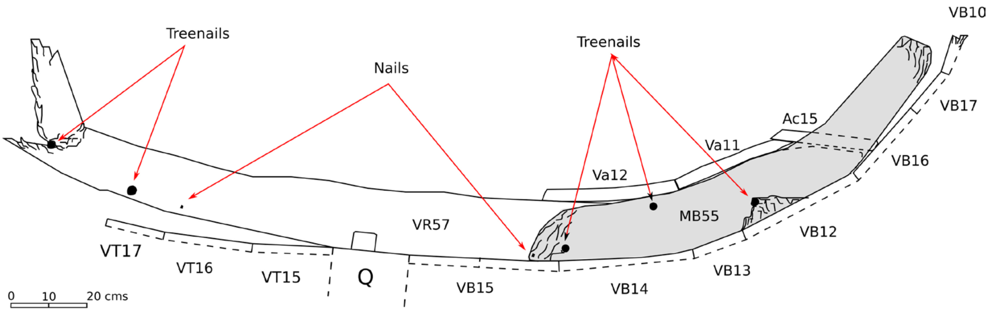

Fig. 1.12. The master frame VR57 (floor timber)/VR55 (futtock)
Source: A. Poletto

Another particular and also very important characteristic of the frames of the *Erquy* boat is the absence of any connection of the floor timbers and the longitudinal carpentry, with the exception of two frames at the after end of the hull. The first is the rising floor timber VR61 fixed to the keel by two nails driven from two tetrahedric countersinks cut in the front vertical face, and the second is the crook timber IND82 (Fig. 1.13), the last crook aft, connected to the sternpost knee CE by a nail driven from a similar countersink cut in the front vertical face. For all the other floor timbers, preserved or not, no trace of connection to the keel has been identified. The near totality of the frames and, notably, those of the central body of the hull, all «floating» in relation to the longitudinal carpentry and principally the keel, determines the conceptual and structural scheme. As in the case of the futtocks, floating in relation to the floor timbers, that floating characteristic of most of the floor timbers raises questions at the level of the principle of construction which will be commented on in the third part.

Fig. 1.13. The tetrahedral pilot hole in the front end of the sternpost knee
Source: Images Explorations — F. Osada

Two final aspects are to be considered. The first bears upon some characteristics specifically of the five frames sampled and studied in a detailed fashion (VR57, VR59, VR61, VR63 and IND82), and the second on the timber species.

Floor timber VR57, the presumed master section, of 13cm sided breadth and 17cm moulded depth, is preserved for a length of 2.35m, with 1.49m fully preserved on the port side. On the underside of the timber, corresponding to the centre of the keel, a rectangular limber is cut, 6cm broad by 5cm high. The same is found in the other floor timbers located on the keel. In advance of the study of the reconstruction of the form of the presumed master section VR57/MB55, and more globally of the reconstruction of the forms, one can emphasise that that floor timber, visually rising less than all the others preserved, would however seem to possess a certain rising. In a total length of the «line of the flat»[14] estimated as 1.88m, the properly flat central part of the floor timber would be of the order 28cm or maybe close to 15% of the measure of the line of the flat. As to the rising at the extremity of the line of the flat itself, it would be around 12cm or maybe 6.5% of the line of the flat. That presumed master floor timber, given a certain rising, is extended by a futtock with a large radius of curvature at its relatively soft bilge. The two floor timbers VR59 and VR61 situated aft of the presumed master section possess, logically for hull forms, an absence of flat of floor and a more and more marked rising of their arms. We note that these two frames present, besides, a peculiarity: a slight inclination towards the stern of the whole of the floor timber. The floating crook timber VR63, given a semi-circular limber, is placed on the curve of the sternpost knee; its squared foot is cut to accentuate its inclination towards the stern. The crook timber IND82, the last frame aft, rests on the sternpost knee to which it is fixed by a nail. Its foot, strongly squared, reinforces the effect of its inclination towards the stern. We note that this crook timber does not possess a limber and that it is connected at the beginning of the rising arm of the sternpost knee by a treenail driven horizontally. One last characteristic common to the two crook timbers is their summary fashioning into a piece of rather irregular form which gives the impression of a sort of filling up aft, in a massive fashion, than of frames.

Another important aspect to examine concerns the nature of the materials of the frames. In this respect, it is useful to emphasise the suppport of dendrometric analysis to the general study of the architecture of the *Erquy* wreck (Fig. 1.14).

[14] We recall that the «ligne du plat» is a horizontal line of the geometric construction of the form of the floor timber, passing through the upper face of the keel.

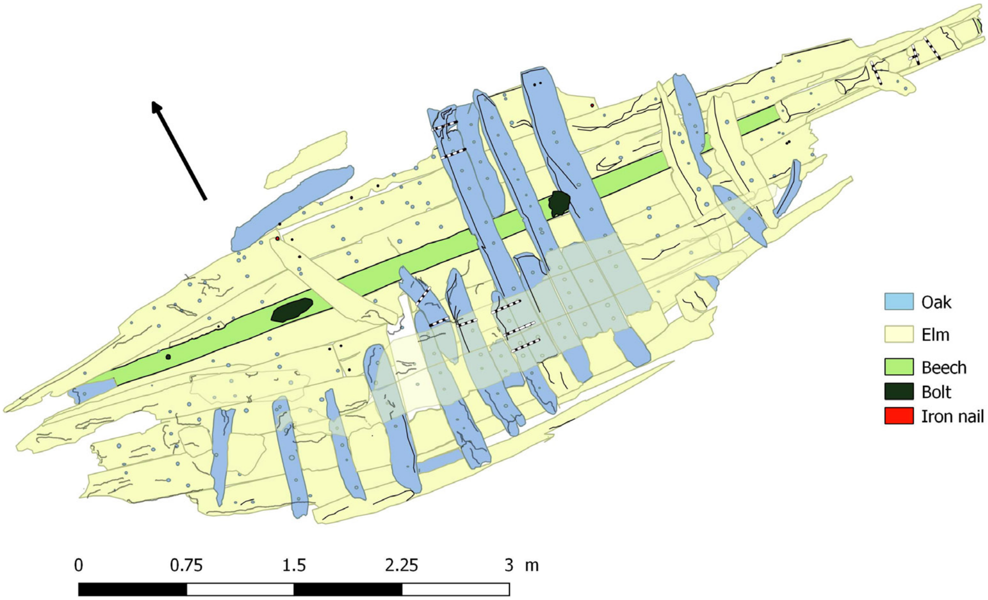

Fig. 1.14. Planimetric view of the various wood species in relation with the architectural remains
Source: Drassm

With the exception of one starboard futtock (MT51) which is in elm, all the other futtocks are of oak. That elm futtock is associated with the floor timber VR58 and the port futtock MB56, which are both of oak. It is difficult to find an explanation for these differences. Was it a question of a repair? Was it a question of an original choice, but then the question is posed of the reasons for using one futtock in elm and one in oak? Was it a question in the end of a constraint connected to the problem of supplying the shipyard? No data allows us to opt for one or the other of the hypotheses.

The floor timbers and the crook timbers have been cut in two materials: oak and elm. The five floor timbers of the central part belonging to the body of the hull (VR55, VR56, VR57, VR58, VR59) are all in oak. The rising floor timbers and the crook timbers (VR60, VR61, VR62, VR63 and IND82) are in elm. It therefore seems that a regular division exists between the two collections of frames timbers. The choice of oak for the floor timbers of the central part of the hull could be connected, perhaps, to certain of its mechanical characteristics, notably its strength in flexure and in compression, two categories of mechanical constraints that are the most frequent to occur on the floor timbers and, in particular, on those of the central part of the hull on grounding.

One last remark concerns the floor timber VR59, the last in oak, whose breadth on the upper face of 18cm is particularly large and, logically, could correspond to a choice to reinforce the transverse carpentry at this point of the hull. One of the hypotheses will be to associate this presumed need for transverse reinforcement of the hull to the placing of a mast and to its constraints on the framing. The studies to come on the reconstruction of the hull and of the rigging of the *Erquy* boat ought to permit more precision on that hypothesis.

2.3.2. The Filling Boards (Fig. 1.15)

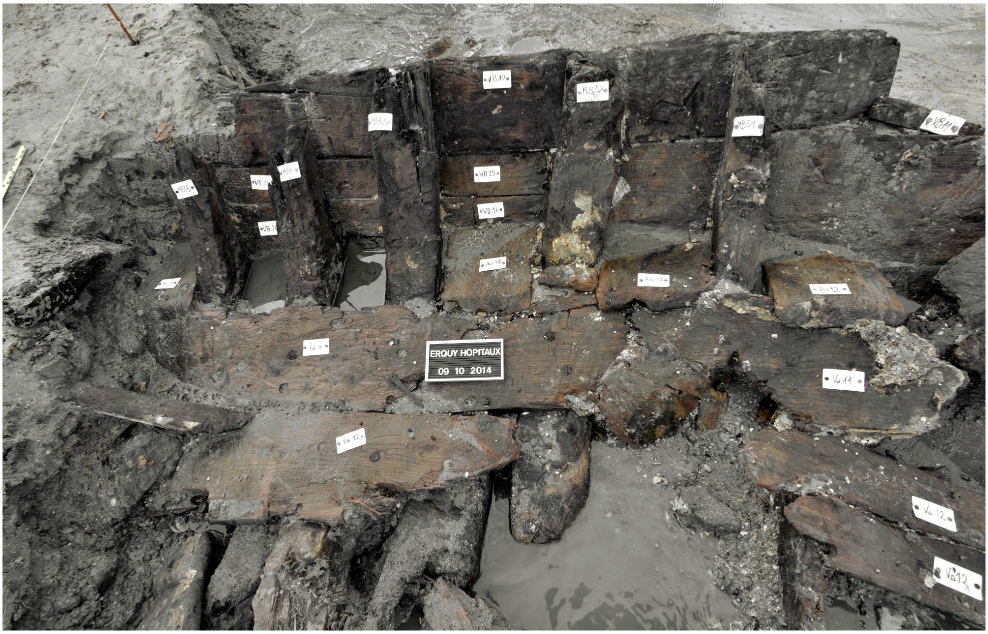

Fig. 1.15. The filling boards (left to right) AC15, C14, AC13, AC12
Source: Images Explorations — F. Osada

In total, nine filling boards (AC10-AC18) of which six are in elm (AC12-AC17)[15] are preserved on the port side. These pieces are simply built in forcibly in the space between futtocks at the upper edge of the floor timbers Va11, Va22 and Va59 which form the ceiling pieces called filling boards. Their length comprises between 24 and 30cm for a breadth of 26cm and a thickness varying between 3.5 and 5cm. Generous as the frames are, these filling boards contribute to the cohesion and reinforcement of the transverse carpentry of the boat[16], assuring a function of protection of the bottom by preventing objects from falling into the space and slipping into the bottom of the hull, risking obstruction of the flow of water to the pump. We add that the full ceiling of the bottom of the hull and the closure of the frame spaces by the filling boards facilitate the loading of loose cargo.

[15] The material of the three other filling boards is not known.
[16] Driven by force into the space, it is a question of compression on the frames. VT13.

2.4. The Side Planking

Along the port side, the best preserved, six strakes are preserved from the keel (VB13-VB10), except in the last quarter aft where only one strake is preserved to port. Along the starboard side, in large part eroded except in the stern quarter where the hull has kept its form in elevation, two strakes only are preserved from the keel (VT15 and VT13)[17] for the whole length of the hull, and a third strake (VT20)[18] is very partially preserved in the centre of the wreck.

These side strakes, arranged in carvel, the broadest of some thirty centimetres, are all in elm with the exception of one piece of plank in oak (VB17A). This piece of planking of reduced length and breadth, situated between futtocks MB52 and MB53, could perhaps correspond to a repair of strake VB11 to the extent where the piece of strake VB17, prolonging the piece VB17A, is in elm like the rest of the strake, and more generally, like the whole of the side planking. The almost general choice of elm for the planking merits some remarks. It is a timber considered as of great quality for shipbuilding[19], and more particularly for long pieces, provided that it is not subjected to alternating periods of humidity and dryness. From a mechanical point of view it is defined as a timber of great longevity, hard, elastic, of excellent strength in flexure and tension, difficult to split and therefore rather difficult to saw[20]. It is a timber that is notably attested in vernacular shipbuilding of northern France for fishing boats that dry out on the beach like, for example, the flobart and the Berck boat, two types of regional boat from the Pas-de--Calais, whose clinker planking is submitted to the abrasive effects of the sand at low tide.

The average thickness of the planks is from 3 to 3.5cm. Numerous traces of pitch have been observed on the planks, as well as vestiges of caulking at the level of the joints between the carvel planks of the bottom towards the fore and aft extremities of the wreck.

Two principal characteristics of this planking are to be emphasised. Firstly, excepting a few cases of iron nails, without regular spacing or correspondence with scarfs, and whose function remains indeterminate, the connections of the planking to the frames are made with oak treenails of 2.5 to 3cm average section. Secondly, the scarfs between the planks are of two types: plain scarf over a frame and overlapping scarf, in a frame space. A representative example of a simple scarf is that existing to port between planks of the garboard strake VB14 at the position of the missing floor timber VR53 which covered it originally. In the case of this scarf, each plank end is fixed to the frame with two carvel nails. A representative example of an overlapping scarf is that of the plank

[17] The next strake above the garboard, VT13, is composed of two planks separated by a simple scarf: VT13 to forward of the axis of the missing floor timber VR53 and VT16 aft of that axis.
[18] The strake VT20 is named VT17 forward of the floor timber VR57.
[19] «[elm] […] this is a timber of first choice for the [boat-]builder, as much for its strength as for the longevity that it assures in the boat» (STEWARD, 1971: 25). In terrestrial construction, this is a timber that is preferred for the making of beams in carpentry.
[20] BALLU, 2000: 59.

VT20, of breadth 36cm. This scarf is situated in the space between floor timbers VR59 and VR60. The scarf is 38cm long on the angle; the height of its overlaps is between 10.5 and 11 cm. A treenail and two carvel nails fixed the plank VT20 west to the floor timber VR59 and a nail connected it to VR60.

Several particular characteristics of this planking are to be considered. The first, and the most significant for the scheme of the structure of the hull, concerns the relatively short length of certain planks of the bottom near the fore and aft extremities. It is very particularly the case for the two garboards VB14 and VB13, whose oblique ends are initially fixed by nailing into the rabbet of the stem. The starboard garboard VT13 of 30cm breadth at its after extremity with a preserved length of 2.37m. The port garboard VB14, slightly narrower (25cm at its after end), measures 2.54m in length (a preserved dimension close to its original). It seems likely that these two planks from the ends of the hull had a more or less analogous length. In these conditions, it would seem possible to interpret these similarities between the two garboards as the result of a technical choice which could be related to a simplification or to the facility of carrying out the work on these strakes connected with the significant narrowing and rising of the bottom of the hull at this point, implying a bending and a twisting of the planks.

We add that the after scarfs of the two garboards VB14 and VT13 are only slightly overlapped on the axis of the floor timber VR53.

At the stern, the closure of the bottom of the hull on the sternpost knee in modifying the perimeter of the side has led to the addition of a pointed steeler in the prolongation of the garboard VT13. This trapezoidal plank measures 1.33m total length, 44.5cm breadth at the aft end corresponding to its position in the rabbet of the sternpost, and 16.5cm at its forward end. This plank is fixed to the sternpost knee by two treenails of 2.8cm average section and without doubt, like the garboard, it was connected to the stem by two nails.

The two other particularities of the planking, of a secondary nature, bear firstly on the realisation of a patch carefully cut into a pentagon which is built into the thickness of the butt end of the starboard garboard VT13. This chock of 7cm breadth at the edge of the garboard and 10.5cm height, probably located at a knot which has been cut out, is fixed by a nail. Taking account of the slope of the edge, it is likely that it has been placed after the interior face of the planking. The second detail concerns a repair of the lower edge of the starboard garboard. 42cm long, by 4cm wide, it begins at 87cm from the fore extremity of the keel scarf. That fitting is fixed to the keel by two nails.

2.5. The Ceiling

A ceiling is very partially preserved in the port half of the wreck only. In total three ceiling strakes are preserved in place either high or low: Va11/Va22/Va59, Va12/Va32 and Va23. All these ceiling strakes are in elm. Their average thickness is 4cm, relatively heavy for the length of the boat. Their average breadth is 29cm. These ceiling strakes are fixed to the floor timbers and futtocks by means of treenails in oak with a section of between 2.5 and 3cm. In the structural scheme these strakes assure a reinforcing function at two levels.

The first is that of the transverse carpentry. The strakes are in effect placed at the position of the overlap of floor timbers and futtocks, and contribute from this fact, in all logic, to the reinforcement of that part of the transverse carpentry, of which it is necessary to recall its floating character, and therefore the relative structural weakness, which affects the majority of the floor timbers in relation to the keel on the one hand, and on the other to the overlap (without connection) of most of the floor timbers and futtocks. The second aspect is that of the longitudinal reinforcement of the hull, and also of its rigidity, associating the internal ceiling and the external planking. This structural role of the ceiling is emphasised, it should be recalled, in numerous marine treatises and dictionaries. It is thus that Bonnefoux and Paris, in the article «vaigrer», specify in their dictionary that «To ceil a ship is to apply planks, to add to the connection, to the solidity of its structure»[21]. In this respect, it is certain that the direct connection between the planking, the frames and the ceiling by treenails passing through the three thicknesses of timber would amplify that function. In the absence of a systematic dismantling of the wreck, it is however impossible to have a global vision of such connections. That has only been closely observed at the level of just two treenails.

We add that it is not impossible that a removable limber strake[22] was originally placed in the bottom of the hull between the lower ceiling strake Va23 and the keelson. Taking account of its mobility, this strake could have been destroyed.

3. THE ARCHITECTURAL REMAINS: ANALYSIS AND INTERPRETATION

Following a methodological distinction regarded as classic, it is important to envisage the analysis and interpretation of the *Erquy* wreck under two principal aspects: that of the principle of conception on the one hand, and that of the method, or processes of construction, on the other[23]. Concerning the first aspect, a supplementary methodological distinction is to be made between that which relates to the conception of the form of the hull and that which concerns the structure.

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[21] BONNEFOUX & PARIS, 1847: 636.

[22] That removable ceiling plank allows the cleaning of the bottom of the hull in order to avoid the limbers being blocked by objects or sediments.

[23] POMEY *et al.*, 2005: 29ff.

3.1. The Principle of Conception

The forms of the hull: the study of the reconstruction of the lines of the forms (Fig. 1.16), the definition of the hydrostatic characteristics of the boat (Fig. 1.17), and that of the rigging (Fig. 1.18), will begin in close collaboration with Sammy Bertoliatti (a professional ship carpenter) and Pierre Poveda (CNRS).

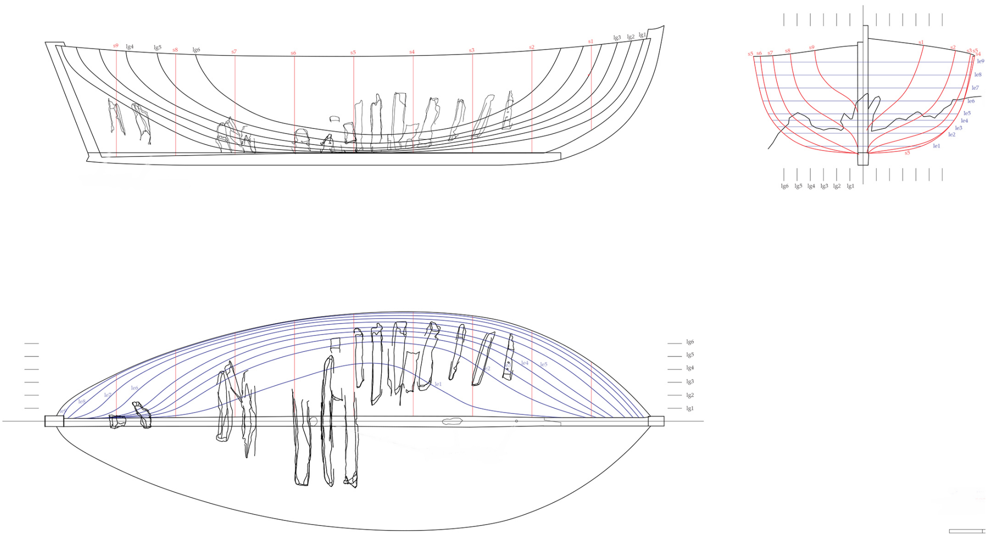

Fig. 1.16. Reconstruction of the lines
Source: S. Bertoliatti

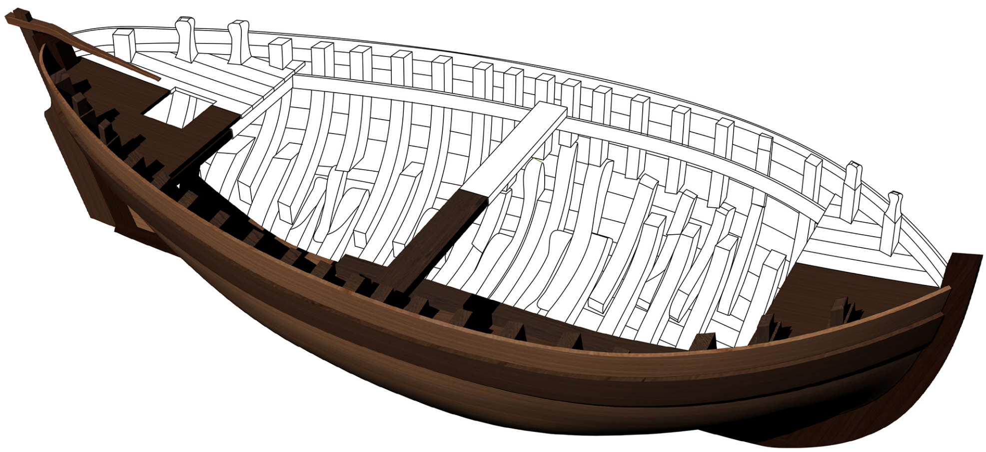

Fig. 1.17. 3D reconstruction of the architectural structure
Source: P. Poveda, AMU, CCJ, CNRS

Fig. 1.18. 3D reconstruction of the coaster *Erquy-les-Hôpitaux*
Source: P. Poveda, AMU, CCJ, CNRS

It appears that two frames, the presumed master-section VR57/MB55 and the frame VR56/MB54, the first frame situated in front of it, which are the only ones preserved in which the futtocks are connected laterally to the floor timbers by treenails and a nail, could have occupied a preferential position in the structural scheme (we will come back to that shortly) and on that of the conception of the forms. Besides, all the other preserved frames are not only «floating» in relation to the keel, but the futtocks also float in relation to the floor timbers. That absence of connection and of transverse cohesion of the frames would seem to suggest that it could be interpreted as an archaeological indicator of the secondary function of these «floating» frames, as much in the structural scheme as in the scheme for the conception of the forms. In this hypothesis, ribbands and/or some strakes of the bottom running from stem to stern, supported in the central part of the hull by the only two predetermined and pre-established frames on the keel

(VR57/MB55 and VR56/MB54), could have contributed to the definition of the forms of the hull, following, consequently, a general perspective of the forms of the hull of longitudinal character. From this, it is clear that in regard to the traditional archaeological classification of the principles of conception, the notion of transverse principle «frame first», such as seems to have been envisaged as normal for a carvel planked boat from the first half of the 17th century, does not seem applicable. The notion closest to that defining the principle of conception of the *Erquy* boat would seem to be that of «proto (or pre-) frame first» to a transverse perspective of the forms of centre of the hull alone, an important part of the conception of the forms (especially towards the ends) still rested on the ribbands (and/or some strakes), according therefore to a longitudinal perspective.

One last remark is to be made with regard to this presumed «proto (or pre-) frame first» principle of conception of the forms of the *Erquy* boat. At the end of the 18th century, the Spanish author G. Juan described a method of conception of forms, based on the predetermination of the master frame alone, and the use of a system of ribbands of which «a certain amplitude or opening […] [is to be given] […] in the points […] where the two balance frames ought to be placed»[24], somewhat similar to that reconstructed for the *Erquy* wreck, to the extent that G. Juan mentions the position of two balance frames, for which no indication of such usage has been identified in the wreck. According to Juan, that method, which is qualified as particular to the «ancient shipbuilders […] who did not know the art of drawing the plans», being always practised by the builders, notably, he emphasised, «those who build boats and other small vessels», the category to which the *Erquy* wreck belongs.

3.2. The Structure of the Hull

These are the frames which, at the heart of the architectural structure, seem at a first analysis to constitute the basis of the whole of the hull. The frames, from their relatively heavy scantlings or a boat of a little over 7m length of keel bearing on the ground, and their disposition with a rhythm of a little more space than room, seem to correspond, in effect, to a technical choice of heavy construction. Always, this heaviness[25] of transverse carpentry stands in some «passive» way to the extent where the frames in themselves do not form a coherent architectural whole because of their dual «floating» character. The first comes back to the absence of connections between the floor timbers and futtocks with the exception of the two frames VR57/MB55 (the presumed master frame) and VR56/MB54, considered as predetermined. In these circumstances, it does not seem that the notion of the principle of «frame first» transverse conception can be applied to define the transverse carpentry of the *Erquy* wreck. In reality, the frames only possess an effective «active» transverse structural function, principally from their «heaviness», and

[24] JUAN, 1783: 15-17.
[25] According to a reading of naval architecture in treatises of the modern era.

by their assembly to the side planking and to the ceiling, largely by means of the keelson, that is to say by the architectural elements belonging to the longitudinal structure of the hull. Besides, neither does the notion of the principle of longitudinal conception «shell first» seem to take account of the architecture of the *Erquy* wreck. No term or expression of contemporary vocabulary for naval architecture or of the terminology of nautical archaeology seems to permit a definition of the principle of conception and the method of construction of the *Erquy* boat. The whole interest and significance of this wreck lies in that.

3.3. The Method of Construction

As a function of the archaeological data and its analysis from the point of view of the principle of conception, it is possible, as a research hypothesis, to propose a first provisional reconstruction for the principal sequences of construction.

- Placing of the primary axial carpentry: keel, stem, sternpost, sternpost knee;
- Assembly on the ground of the futtocks MB55 and MB54 (and their starboard pairs) to the floor timbers VR57 (the presumed master) and VR56;
- Putting these two predetermined frames in place on the keel and temporary lateral and longitudinal support by means of shores and stays; these two frames are comparable to fixed moulds;
- Either ribbands may be placed between stem and sternpost, which are supported on the outside faces of the two central pre-erected frames, or the bottom strakes placed up to the level of the bilge, supported, as in the hypothesis of ribbands, on the two predetermined frames;
- The rising floor timber VR61 and the crook timber IND82 at the sternpost knee may be introduced, perhaps, and connected to the keel with nails;
- Placing of the «floating» floor timbers fore and aft, whose contour is defined either by the ribbands, or by the strakes of the bottom, and connection of these to the bottom planking;
- The keelson is put in place and bolted to the keel through three frame spaces;
- The bottom planking is placed and connected, up to the bilge;
- Introduction of the floating futtocks and their connection to the bottom planking;
- Proceed with raising the side planking, perhaps with the concurrent placing of the ceiling and of connection through certain ceiling strakes to the planking;
- Introduction of the filling boards by force.

The absence of preservation of architectural remains renders the reconstruction of the sequences of the chain of constructional operations completely hypothetical. We will therefore terminate the reconstruction there.

PROVISIONAL CONCLUSION

At the end of this first phase of the study of the architecture of the *Erquy* wreck, several aspects are to be emphasised. It can be stated first of all that the *Erquy* wreck, from the first half of the 17th century, possesses a series of particular architectural characteristics with respect to those technical sources coming notably from treatises of naval architecture[26], put in evidence, and lead us to consider as representative of the whole of architectural practices of the modern era.

The particular principal architectural characteristics are as follows:

Architectural Element	Particular Characteristics
Keel	Partial rabbet
	Open mortise for the tenon of the sternpost
	No trace of connection of the floor timbers to the keel
	3 bolts for connection of the keelson
Keelson	Bolting through the frame spaces at 3 points
Frames	Position of all the futtocks on the front vertical faces of the floor timbers
	No connection of the floor timbers to the keel except the rising floor timber VR61
	No connection of the futtocks to the floor timbers except the presumed master section (VR57/MB55) and the first frame forward of that (VR56/MB54)
	Central floor timbers in oak
	Other floor timbers and crook timbers in elm

These particular characteristics, and especially the frames floating in relation to the keel, do not permit us to attach the architectural principle of the *Erquy* boat to the customary characteristics proper to the principle of «frame first», as that is classically defined in terms of analysis and of archaeological interpretation. The central question that is posed from that is that of the meaning to give to these particularities which appear, indeed, well outside the architectural norms defined by the historical sources, principally manuscript, of the era. Is it a question of isolated characteristics, specific to one shipyard, even to one constructor, or, on the contrary, is it a question of characteristics of a more general extent, and assimilable to the «architectural signatures» capable of expressing construction practices of a regional character? The *Erquy* wreck remaining for the moment as an archaeological one-off, no response can be proposed to that

[26] These sources are, it is true, later than the dating of the *Erquy* wreck. In France, the first work published and considered as a treatise of naval architecture is that of DASSIÉ, 1677. It is a purely theoretical work which addresses itself not to practitioners of shipbuilding, but to future naval officers (cf. RIETH, 1997: 15-27).

question. Now, is it necessary to emphasise that the scientific gamble was of importance in the scheme of the history of naval architecture to the extent where the *Erquy* wreck represents an architectural type, that of a boat destined for a regional coastal navigation, or, to a more limited scale of navigation, representative of a fleet of hundreds of units of comparable dimensions, constituting the fabric of the economic base of maritime transport of the modern era. It suffices to consult a commission as for example, that organised by Colbert in 1664, setting out a quantitative table of the vessels by port, for account to be taken of the numeric importance of the role of these coasters in the maritime economy of France in the «Ancien Régime».

With regard to boats of moderate tonnage, the archives attest that it was not exceptional that partially decked sailing vessels of a dozen tons to undertake navigations to destinations, very far distant from their home ports or harbours. The *Erquy* wreck can be included in this category. The dendrochronological analysis has made it appear, indeed, that the elms that served for the construction of the *Erquy* boat could have come from a forestry area corresponding to the present Pays de Loire. In the hypothesis, coherent in the case of a boat of reduced size, revealing a vernacular architecture, from a situation of relative proximity between the place of supply and the site of the shipyard, the *Erquy* boat could thus very well have been constructed in the Pays de Loire, somewhere between the departments of Loire-Atlantique and the Vendée.

In terms of that presentation, it can be stated therefore that in relation to the absence of the written and graphic sources, only archaeology is capable of reconstructing, in a certain more or less complete fashion, the architecture of these coasters in their more technical aspects. The *Erquy* wreck is a perfect illustration of the role of archaeology in extending knowledge of the history of naval architecture of the modern era on the one hand, and of its importance in the re-reading of a technical history too often considered as too well known and definitive to make appeal to the archaeological sources on the other. Of the other wrecks from the Atlantic arc, in other geo-historical contexts than that of the *Erquy* wreck, belonging more to that archaeological category of one-off, have led to a re-reading of history, considered as received, from the naval architecture or at least to a renewal of its interrogation. This is the case, for example, of the *Port Berteau II* wreck, dated from the beginning of the 7th century, situated in the river Charente. That wreck of a fluvio-maritime coaster, from its carvel construction of «frame-first» type, posed the question of its place in the chronology of the history of «carvel» naval architecture in the Atlantic arc.

The field of archaeological research will favour numerous future beneficial discoveries.

ACKNOWLEDGMENT

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PRIMARY SOURCES

MUSÉE Nacionale de la Marine — *Baleau de Lanvéoc*, *vers 1830*, inv. n.º 3, cp. 5.

EDITED SOURCES

BALLU, J. M. (2000) — *Bois de marine. Les bateaux naissent en forêt*. Paris: Gerfaut.

BELTRAME, Carla, *ed*. (2014) — *Archeologic dei relatti postmedievali*. «Archeologia Post Madievale», vol. 18. Firenze: All'Insegna del Giglio.

BONNEFOUX, B.; PARIS, E. (1847) — *Dictionnaire de marines à voiles*. Paris: Éditions du Layeur.

CHAPMAN, F. H. af (1788) — *Traité de la construction des vaisseaux*. Brest: R. Malassis.

DASSIÉ, C. (1677) — *L'architecture navale*. Paris: n. p., 1677.

JUAN, G. (1783) — *Examen maritime théorique et pratique, ou traité méchanique appliqué à la construction et à la manœuvre des vaisseaux et autres bâtiments*. Nantes: [s.n.].

MORINEAU, Pierre (2010) — *Répertoire de construction, 1752*. Paris: Éditions Ancre.

PÂRIS, Admiral F. E. (1882) — *Souvenirs de Marine Conservés*. Paris: Gauthier-Villars, vol. 1.

POMEY, P.; RIETH, E.; RIVAL, M. (2005) — *L'archéologie navale*. Paris: Errance.

RIETH, E. (1985) — *L'archéologie sous-marine post-médiévale*. «Cols Bleus», n.º 1858, p. 7-11.

_____ (1997) — *De la Fabrica di Galere (XV^e^ siècle) au traité de C. Dassié (1677): rupture ou transition?* In ACERRA, M., *ed*. — *L'invention du vaisseau de ligne, 1450-1700*. Paris: SPM, p. 15-27.

_____ (1998) — *Construction navale à franc-bord en Méditerranée et Atlantique (XIV^e^-XVII^e^ siècle) et 'signatures architecturales': une première approche archéologique*. In RIETH, E., *ed*. — *Méditerranée antique. Pêche, navigation, commerce*. Paris: Éditions du CTHS, p. 177-188.

STEWARD, R. M. (1971) — *Construction des bateaux en bois*. Camden: International Marine Publishing.

WESTERDAHL, C. (1995) — *Traditional zones of transport geography in relation to ship types*. In OLSEN, O.; RIECK, F.; MADSEN, J. Skamby, *eds*. — *Shipshape: Essays for Ole Crumlin-Pedersen*. Roskilde [Denmark]: Viking Ship Museum, p. 213-230.

CONTRIBUTION TO THE ARCHITECTURAL STUDY OF *RIA DE AVEIRO A*, A MID-15TH-CENTURY PORTUGUESE SHIPWRECK

FRANCISCO J. S. ALVES

INTRODUCTION

The remains of *Ria de Aveiro A* shipwreck were casually discovered in 1992 by Carlos Neves Graça, a local resident, in the vicinity of the «Englishman's beach» (*Praia dos Ingleses*), which is at the end of the Mira channel of Aveiro Lagoon (Figs. 2.1 and 2.2). In the next year the wreck remains were formally identified during an extreme low tide of 0.3m (Fig. 2.3), when they were visible at the surface. Between 1996 and 1999 those remains were all excavated (Fig. 2.4), recorded and carefully collected under the direction of the A., and promptly dated by radiocarbon as being from the mid-15th century (ICEN-1105/1116/1117/1118).

Fig. 2.1. The Aveiro lagoon in the Iberian Peninsula map
Source: Deutsches Archäologisches Institut (original map)

Fig. 2.2. Archaeological site of the *Ria de Aveiro A* shipwreck
Source: Aveiro Harbour Administration

Fig. 2.3. View of the ship remains in an extreme low tide of 0.3m, in 1993
Source: Francisco Alves; CNANS

Fig. 2.4. Underwater view of the remains (the heel in the foreground) completely uncovered and recorded, just before their archaeological dismantling in 1999
Source: Guilherme Garcia

In 1999 all the structural remains of the ship were transported to the conservation laboratory of the *Centro Nacional de Arqueologia Náutica e Subaquática* (CNANS) in Lisbon, created in 1997 as a part of the *Instituto Português de Arqueologia* (IPA) of the Ministry of Culture[1]; in 2001 two very comprehensive papers about the research developed until then were published[2]; and in 2003 the structural wooden remains of *Ria de Aveiro A* shipwreck underwent the classical conservation treatment with poly-ethylene-glycol (PEG) which was concluded in less than a decade. Nevertheless, today those remains are still lying in the original PEG solution, with the implicit risk of degradation[3].

The area of the finds (Fig. 2.5) had its major axis oriented 22º Nmg, and was spread along 10.4m, from the stern extremity to the north till the terminal hull planking elements to the south. This preserved part of the hull is composed by 23 transversal elements (frames, peak-floors and futtocks) and 31 planks, some of them incomplete, and preserved *in situ* in a maximum width of c. 2.5m.

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[1] António Guterres, recently elected Secretary-General by the General Assembly of the United Nations Organization, was the Prime-Minister at that time. IPA and CNANS were created in 1997 as part of the Portuguese Ministry of Culture. However, with the IPA extinction in 2007, CNANS saw his institutional profile being diminished.

[2] ALVES *et al*., 2001a; ALVES *et al.*, 2001b.

[3] See *infra*: *Addendum*.

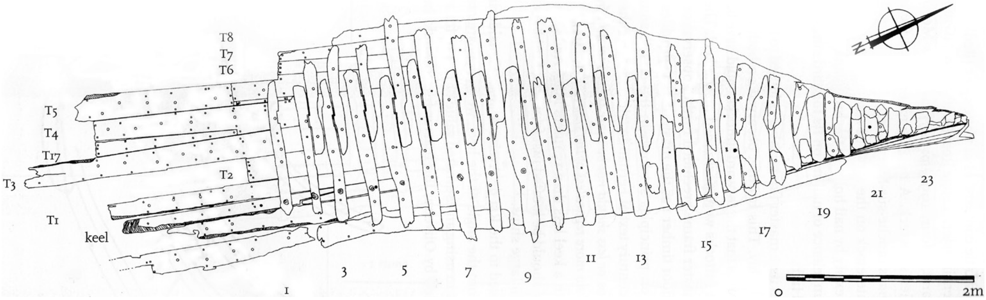


Fig. 2.5. RAVA. Plan of the architectural remains
Source: ALVES *et al.*, 2001: 327

Those elements corresponded to a little more than the aft half of a hull bottom of a ship, lying *in situ* with a lateral starboard side inclination of c. 15º, and a longitudinal stern inclination of c. 3º to 6º. For this reason, the starboard hull planking was buried deeper in the sediment, and much better preserved here than in the portside — the same happened longitudinally, with the *couce de popa* (the heel) (Fig. 2.6) more buried than the fore planking, which raised at the surface of the sediment. This *couce* could not be more similar to the one represented in the classical manuscript by João Baptista Lavanha, *Livro Primeiro da Arcuitectura Naval*[4] (Fig. 2.7), of the early 17th century.

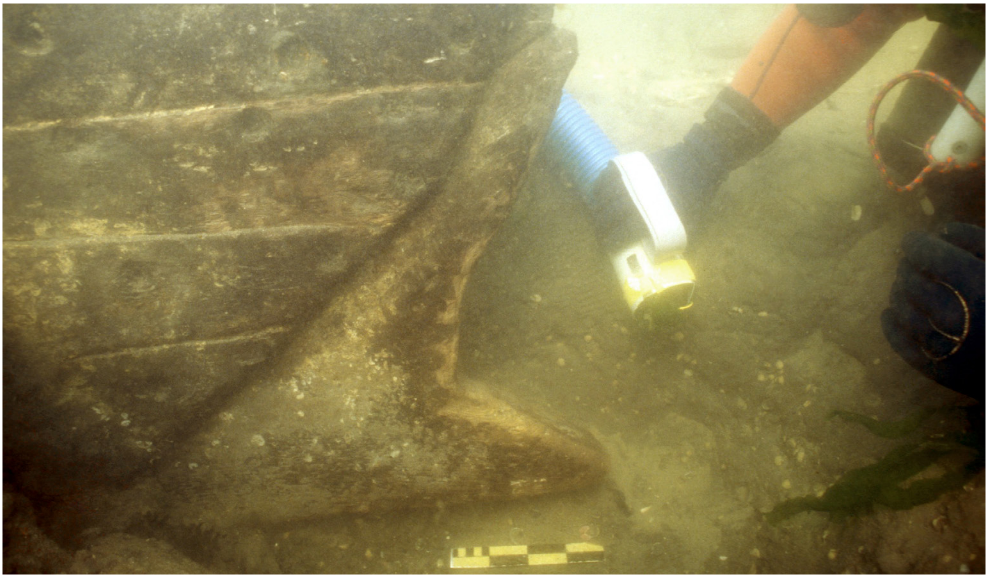


Fig. 2.6. Underwater view of the terminal part of the heel of RAVA
Source: Francisco Alves

[4] BARATA, 1996: 62v-63.

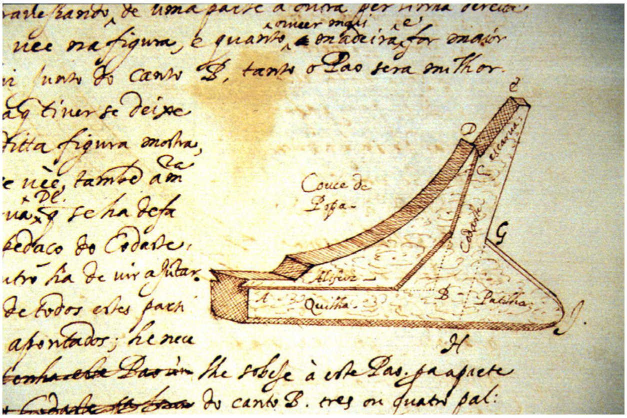


Fig. 2.7. Heel (with its stern-knee) drawn by Lavanha in his treaty of the early 17th century
Source: BARATA, 1996: 45, fig. 10 e fig. 63

This kind of heel (*couce de popa*) is present in Portugal in two other instances: a) the 1985/1986 dredges in the *Varadouro* area of the estuary of river Cávado, close to Esposende[5] (Fig. 2.8), when the first *couce* of this kind was found in Portugal — their two main pieces, the heel (*couce*) and the stern knee (*coral*), although disassembled, had survived; their radiocarbon dating points to the 16th century/1st half of the 17th century (Beta-143087); b) the *Corpo Santo* shipwreck, discovered in 1996 during excavation works in the Lisbon riverside (Fig. 2.9), and dated from the 14th century by radiocarbon (Sac-1361), which had a shape very similar to the *Aveiro A* one.

Fig. 2.8. Heel and stern-knee of *Varadouro* shipwreck (river Cávado estuary, Esposende), 16th century/1st half of 17th century
Source: Ivone Magalhães

[5] This «couce» was the first discovery of this kind occurred in Portugal. The A. thanks Ivone Magalhães and José Salgueiro, a local witness, for the information they kindly provided.

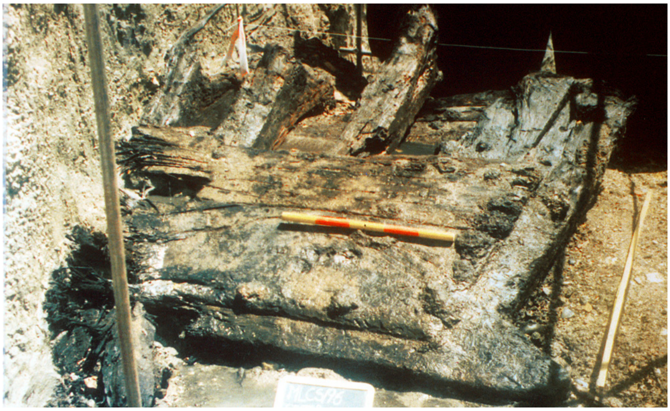


Fig. 2.9. Heel of *Corpo Santo* shipwreck, 14th century
Source: Francisco Alves

A significant part of the *Aveiro A* keel has survived in a length of 9.15m, a little less than the full length of the planking (c. 10.4m). It was a composite piece, made of segments linked through vertical plain scarfs, reinforced by transversal iron nails of square section (Fig. 2.10), a system also illustrated by Lavanha. The last aft element of the keel integrated the heel. A small segment of the keelson had also survived (Fig. 2.11). This one was originally fixed to the axial top of the frames (Fig. 2.12), which were fixed to the keel by similar iron nails, inserted vertically into the frames 1-9, and obliquely into the frames 10 to 18, in grooves carved in their fore faces, and into the frames 19-21 in their aft faces. The whole was assembled by thick iron bolts — of circular section vertically inserted from the top of the keelson into the base of the keel with their extremities hammered over iron washers, reason why they were called *anielados*.

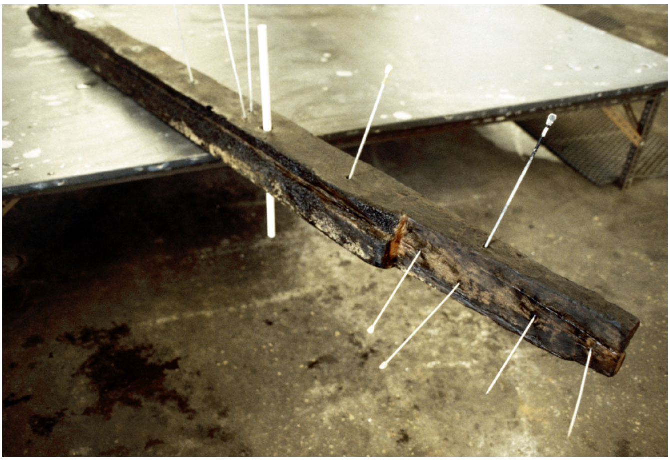


Fig. 2.10. Segment from the keel of *Ria de Aveiro A* with vertical scarfs in their extremities
Source: Francisco Alves

Fig. 2.11. A segment of the keelson of *Ria de Aveiro A* where the rectangular sloping carving for the deck post sliding can be seen
Source: Francisco Alves

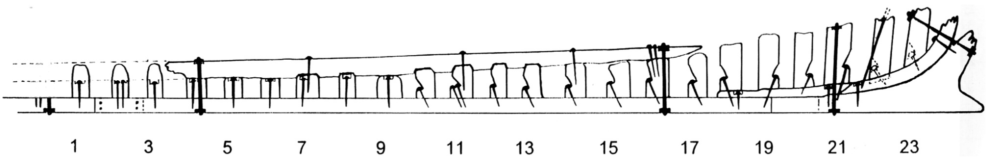


Fig. 2.12. RAVA. Axial section of the preserved structure of *Ria de Aveiro A* with its iron nailing system
Source: M. Aleluia, rev. Francisco Alves

The preserved framing of the ship was composed by 23 basic elements, among which were the hull frames and terminal peak-floors; the latter were fixed to the curved face of the stern knee (*couce*), with nails following the above described method. All of them were better preserved on the starboard side because they had been buried deeper, reason why most of their first futtocks were in better condition, on this side. The fore frames and futtocks were connected through a triple reinforcement, composed by the classical male-female mortise, typical of the millenary carpentry (called in English «in dovetail» shape, in French «en queue d'aronde», and in Portuguese «em rabo de minhoto», designation due to its trapezoid shape) — a system here symmetrically reinforced by pairs of iron nails of square section, and wooden pegs of circular section (Fig. 2.13).

It was also verified that the position of the different segments of the framing system followed the «Atlantic model»[6] in which the futtocks are always connected with the sides of the frames that face the respective forward or aft extremity of the ship — with the exception of the master-frame, which always has a pair of symmetrical futtocks in each side (Fig. 2.14).

Fig. 2.13. Typical frame-futtock connection, through dovetail mortise and double fastening, with iron nails and wooden pegs
Source: Francisco Alves

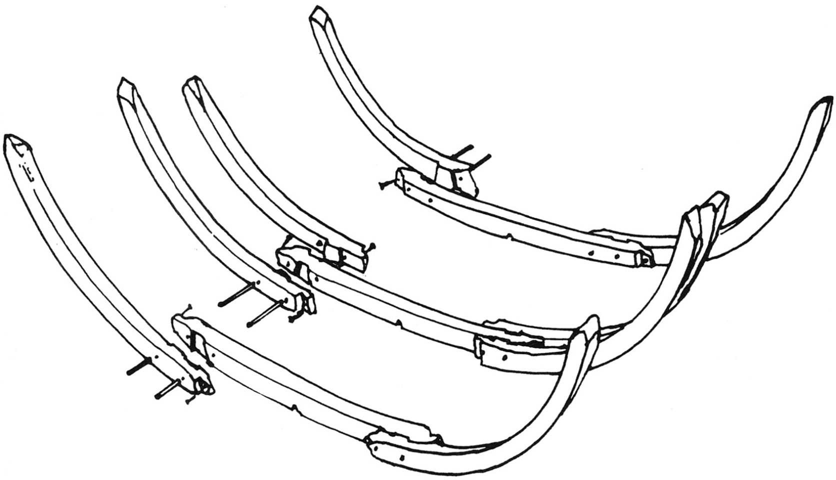


Fig. 2.14. The so-called Atlantic scheme of the master-frame and its adjacent frames
Source: T. Oertling

[6] OERTLING, 2001.

The ship cargo included walnuts and chestnuts, presumably stored in small barrels, from which several staves and half-round wicker hoops (Fig. 2.15) survived. However, the cargo was mostly composed of ceramic pieces of a well-known common ware, typical of the Aveiro region (Fig. 2.16). From this kind of cargo — apparently dominant — the recovered part constitutes the largest, most diversified and best preserved collection of ceramics of this type, from the Portuguese Late Medieval and Renaissance times, with a national and international very well-known diffusion, especially at European and transatlantic level, which is now archaeologically attested[7].

Fig. 2.15. Wooden barrel stave and fragments of wicker hoops
Source: Francisco Alves

Fig. 2.16. Typical common earthenware production from the Aveiro region
Source: Francisco Alves

[7] The preliminary research on the ceramics recovered inside and outside the ship hull, from the stern part of the shipwreck till the skeg base, was led by the A. After the archaeological dismantling of the ship hull in 1999, the dispersed but compacted area of the cargo, spread around the original hull location, was carefully excavated by Patrícia Carvalho and José Bettencourt, members of CNANS at that time (ALVES *et al*., 1998; CARVALHO & BETTENCOURT, 2012).

Finally, it was possible to prove archaeologically that the ship was lost in the sequence of a fire occurred on board, attested not only by the melting, re-cooking and cooling of numerous ceramic vases retrieved, completely deformed but intact, and sometimes welded to other ones (Fig. 2.17), but also by traces of fire in the inner faces of several preserved hull planks of the starboard side, corresponding to the cellar (Fig. 2.18).

Fig. 2.17. Two bowls deformed and welded in consequence of a fire in the cargo hold
Source: Francisco Alves

Fig. 2.18. Fragment of a starboard side hull plank burnt on its internal face
Source: Francisco Alves

1. THE *RIA DE AVEIRO A* SHIPWRECK: FEATURES AND ORIGINS

The first three frames partially preserved in the fore side of the remains, emerging from the sediment, in their portside rupture extremities (originally located axially) presented horizontal plan surfaces, clearly obtained by intentional lowering (Figs. 2.19 and 2.20).

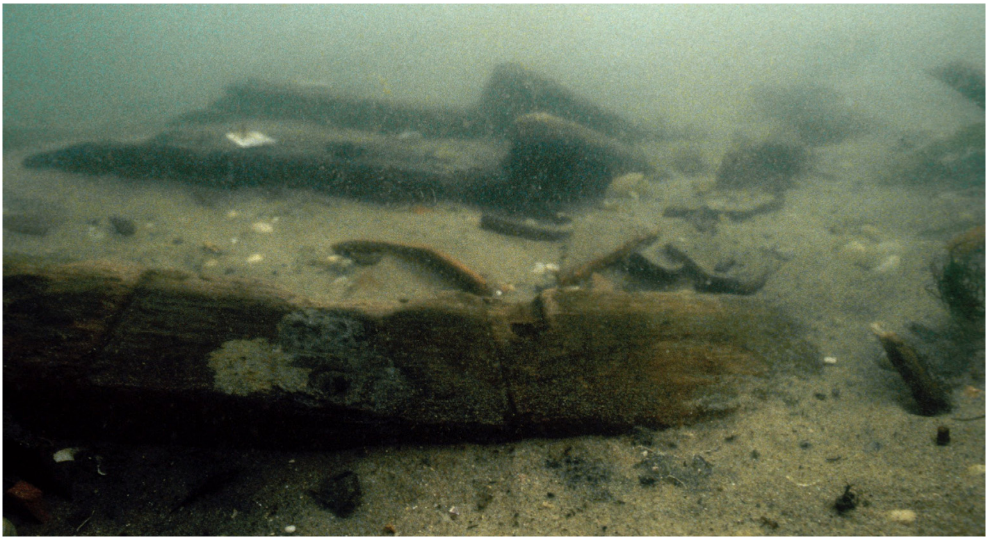


Fig. 2.19. Subaquatic aft-fore view of the first three starboard side frames partially preserved in the fore part of the remains (1 to 3)
Source: Francisco Alves

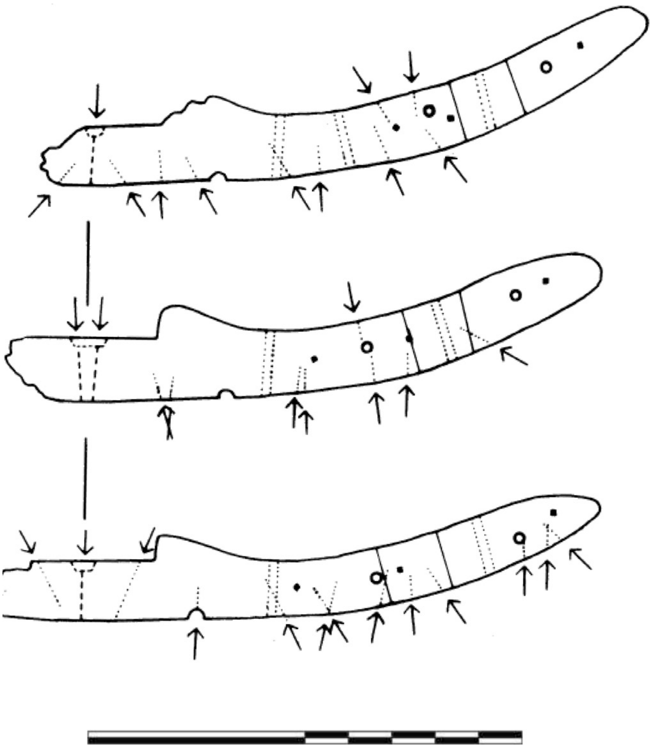


Fig. 2.20. Drawing of the axial-transversal sections of the first three partially preserved frames
Source: M. Aleluia

Those lowered horizontal surfaces were immediately contiguous, in their starboard side, to abrupt vertical protuberances (*buttresses*) that progressively reached, in that direction, the original vertical thickness of the frames. In fact, originally, they were the axial parts of the three first partially preserved fore-frames. Those lowered spaces between the original symmetrical buttresses served to host the enlarged part of the keelson (the mast step, *carlinga* in Portuguese) in whose hole (*pia*) the mast foot was inserted. This system is very well documented in the inside of the hull of the *Contarina 1* shipwreck of the Italian Po delta, dated from the 13th century, recovered during an excavation in 1898[8] (Figs. 2.21 and 2.22).

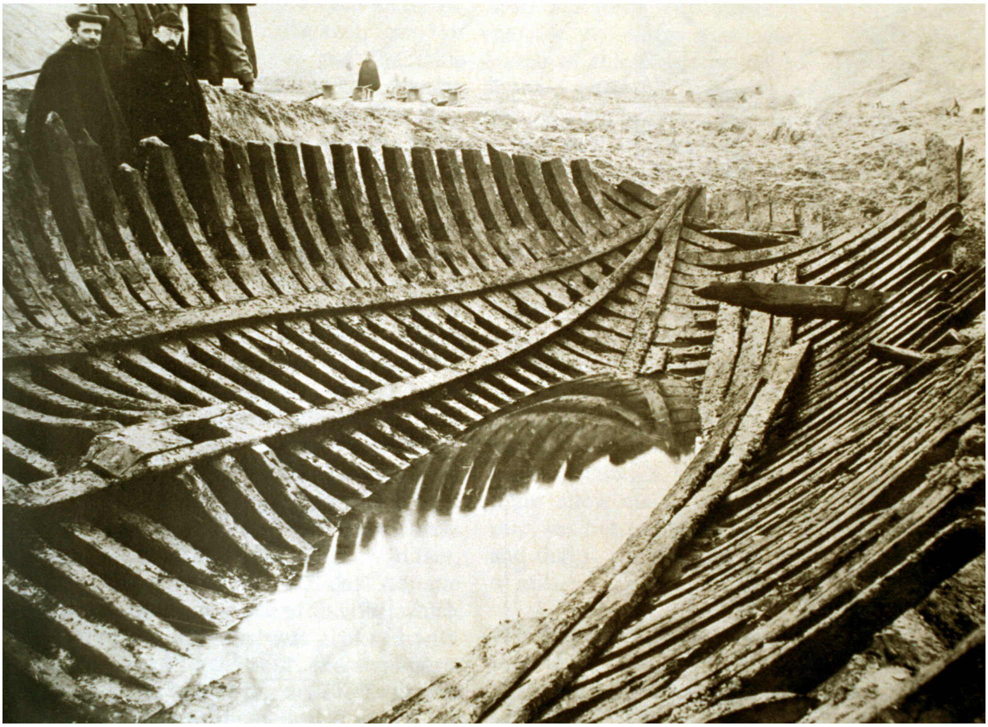


Fig. 2.21. View of the hull bottom of the *Contarina 1* shipwreck in the River Po delta in 1898
Source: BONINO, 1978: 13, Fig. 3

[8] BONINO, 1978.

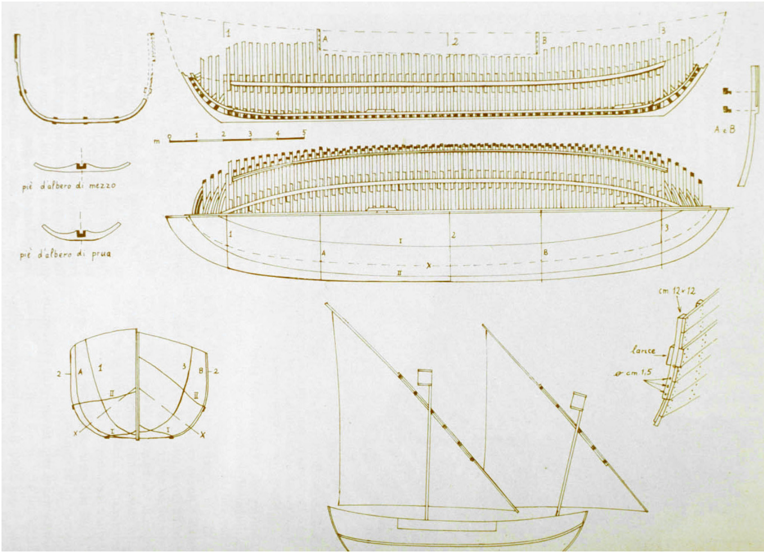


Fig. 2.22. Drawings and graphic reconstruction of the *Contarina 1*
Source: BONINO, 1978: 14, Fig. 4

As it can be observed, the internal axial structure of *Contarina 1* presents notorious similarities with the equivalent preserved part of *Ria de Aveiro A*, although this one was not so well preserved — that part of the keelson in the three fore-frames being only attested in negative by their keelson encasement spaces. This is well documented by the drawings of the transversal sections of those three partial frames of *Ria de Aveiro A* (Fig. 2.20), and especially in their detailed plan (Fig. 2.23) which also proves that the first of those partially preserved frames (the lower one of Fig. 2.20 and the number 1 of Fig. 2.23) corresponded to the master-frame.

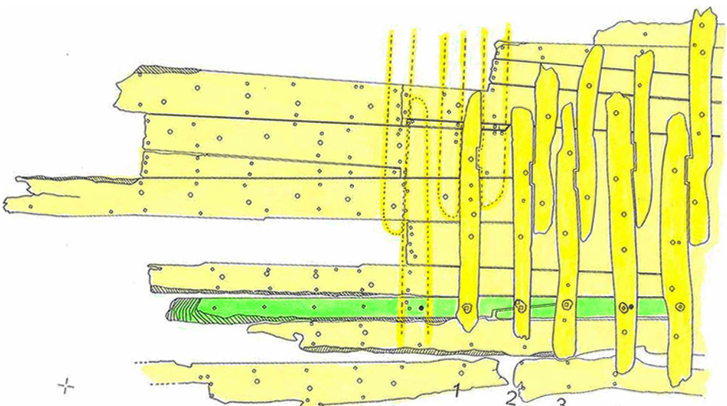
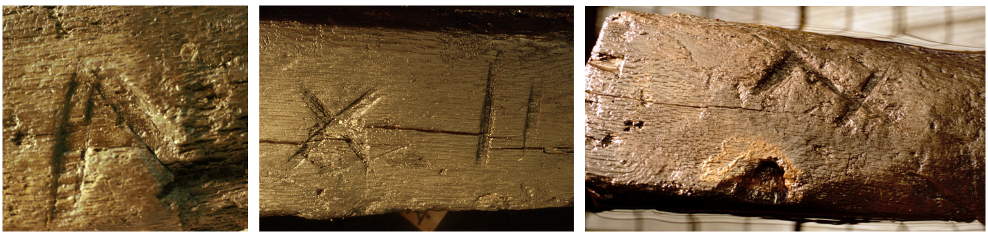


Fig. 2.23. Detailed plan of the extreme fore part of the architectural remains
Source: Francisco Alves

In fact, this first fore frame, partially preserved, was the only one, among all the frames, that originally had on each side (fore and aft) two symmetric futtocks (fixed in their aft and fore faces) — whose presence in negative was attested by the holes of the iron nails that fixed the subjacent outer planking to the base of those frames. Those holes are clearly visible on the drawing. This detail of architectural symmetry of this pair of futtocks of the master frame, as already referred, is common to all known ships of the Iberian-Atlantic ship building tradition[9]. It must be also referred that the missing frame (the fore — first preserved frame) — equally attested in negative by the respective iron nails holes (Fig. 2.23) — should be, in all, identical to the frames numbers 2 and 3, originally existing in their exact symmetry. Therefore, they would together constitute the original bed of the ships keelson, as we can observe in *Contarina 1*, in which this axial part of the ship structure was completely preserved.

It is worth to note also that Father Fernando Oliveira, author of the oldest and most famous Portuguese treaty of naval architecture, *O Livro da fabrica das naos*, of 1580, clearly states that the master frame of a ship must always be placed at 1/8th fore amidships. Consequently, counting for a length in Portuguese classical *rumos* of naval architecture (1 *rumo* measuring c. 1.54m), *Ria de Aveiro A* shipwreck could only have a keel of 8 *rumos* (12.32m), since the measures of 7 or 9 *rumos* were either insufficient or excessive in length to be compatible to the dimension of the preserved part of *Ria de Aveiro A* shipwreck.

Another detail — of important architectural meaning — was the presence (on different designated on the plan by the numbers 5, 12 and 15) of the Latin numerals «V», «XII» e «XV» engraved by excision (Figs. 2.24a, 2.24b and 2.24c)[10], whose specific architectural meaning was initially not clear, independently of their obvious generic significance in the architectural sequence (Fig. 2.25).



Figs. 2.24a to 2.24c. Latin numeric marks (V, XII and XV) engraved by excision in the preserved frames 5, 12 and 15, as indicators of position in the architectural sequence
Source: Francisco Alves

[9] The exceptions would be ships with more than one master-frame.
[10] Identical numeration on *Cais do Sodré* shipwreck, and on the wreck of the Portuguese Indiaman *Nossa Senhora dos Mártires*, was incised, instead of excised as seen in *Ria de Aveiro A*.

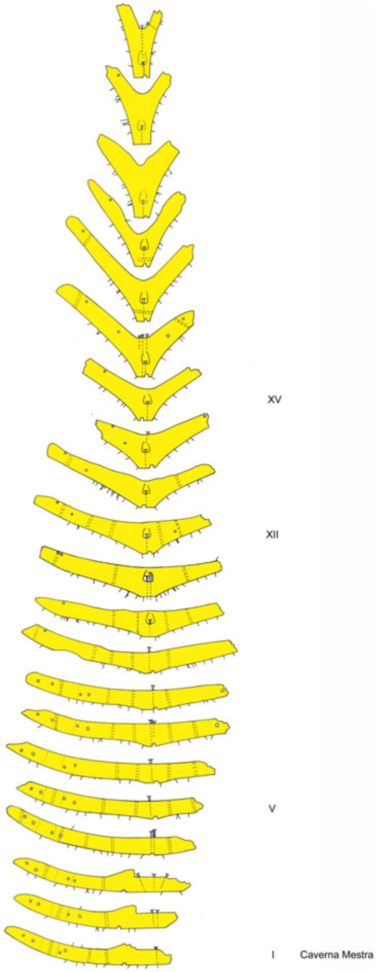


Fig. 2.25. Architectural sequence of the preserved frames, represented by the respective transversal sections Source: Francisco Alves

This kind of shipyard's criterion of identification was already archaeologically attested in the *Culip VI* shipwreck, at the Catalonia coast, dated from the end of the 13th century[11]. In Portugal it has also been recorded in the *Cais do Sodré* shipwreck[12], from the late 15th to mid-16th century, and in the presumable Indiaman *Nossa Senhora dos Mártires*, wrecked in 1606 in the Tagus bar[13].

All those details, testemony of a well-known architectural conception of Late Middle-Ages Mediterranean origin, allow an hypothesis about the constructive genesis of the *Ria de Aveiro A* ship. Indeed, its relative modest dimensions and the rough shape of its framing timbers allow us to admit that the ship could have been built in a modest

[11] NIETO & RAURICH, 1998.
[12] RODRIGUES *et al*., 2001.
[13] ALVES, 1998; CASTRO, 2001.

local shipyard of the Atlantic or the Mediterranean Iberian coasts. This hypothetical origin also allows us to admit that the building of this ship could be based on a tradition perhaps even earlier than the mid-15th century.

Finally, it seems acceptable to admit[14] that *Ria de Aveiro A* constitutes so far the closest and most coeval example of what would be a caravel of the *Quattrocento* Portuguese Atlantic explorations.

* * *

This was the state of the question until 2015. However, in this year, the A. was invited to give two lectures on nautical archaeology and naval architecture of Portuguese tradition in a seminar organized by the University of Cadiz[15], where he presented five shipwrecks found in Portugal (*Corpo Santo*, *Ria de Aveiro A*, *Cais do Sodré*, *Nossa Senhora dos Mártires* and in the Oranjemund coast of Namibia[16]), with a brief reference to the works of Fernando Oliveira and João Baptista Lavanha. Along with the preparation of those themes, when revising the graphic documentation of *Ria de Aveiro A* shipwreck, and facing the diversity of scales published, the A. decided to draw a scale based on the real dimensions of the remains and place it all along the shipwreck plan (Fig. 2.26).

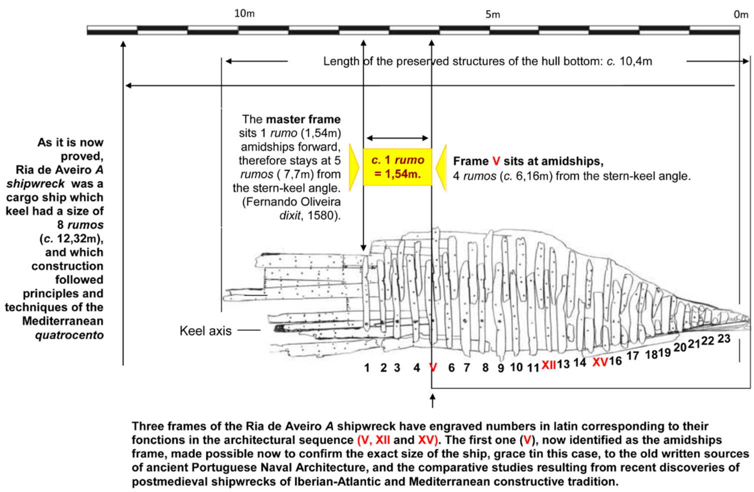


Fig. 2.26. *Ria de Aveiro A* shipwreck plan, reviewed and annotated by the A. (for Cadiz seminar, 2015)
Source: Francisco Alves

[14] Despite the obvious reserve about the effective shipyard origin of most of ancient shipwrecks found everywhere.
[15] The seminar *The origin and development of Naval Architecture (September, 7-11)* was organized in collaboration with other important provincial institutions, under the coordination of Javier Nieto, ancient director of ARQVA (Cartagena) and CASC (Girona), a colleague and friend since 1982 (Europe Council UCH-Course of Neuchâtel and Marseille).This meeting has been an opportunity to listen to some invited reputed friends (Patrice Pomey, Cemal Pulak, and Francisco Fernandéz González).
[16] ALVES, 2009a; ALVES, 2011; ALVES, 2013.

Only then, after having traced at 6.16m the half-keel mid-vertical line, the A. realized that it was situated exactly over the frame that had the numeral «V» engraved (Fig. 2.24a.); for the first time, he understood that this numeral corresponded to the exact amidships frame. This observation was also coincident with another one, subsequently confirmed by Eric Rieth[17] — in 2003 he had remarked that in the plywood model at 1:1 scale (called 2D[18]), the bottom arch of the ship hull was rising exactly at the frame 5 (Figs. 2.27 and 2.28).

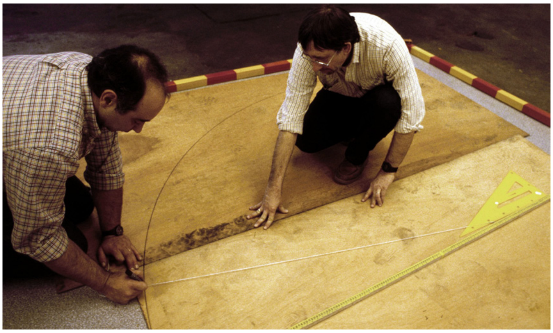


Fig. 2.27. Eric Rieth and Paulo Rodrigues testing the curvature of the first frames of *Ria de Aveiro A* shipwreck, with the help of a mould of the master-frame, in the plywood model at 1:1 scale, said «in 2D»
Source: Francisco Alves

Fig. 2.28. View of the 2D and 3D models of the preserved framing at the CNANS facilities in 2004
Source: Francisco Alves

[17] Information transmitted to the A. by E. Rieth, during the elaboration of the present text.

[18] Two models at 1:1 scale of the basic structure of *Ria de Aveiro A* shipwreck were conceived by the A. and were executed under his supervision in CNANS facilities in 2003-2004 (Fig. 2.28.). The 2D model remained exposed there until 2010, when CNANS moved from Belém to Loures (See *infra: Addendum*). In this model all the frames were made of plywood, regardless of its thickness which did not correspond to the original longitudinal thickness of each frame. The frames and peak-floors were also cut out from a plywood sheet where the drawings (in 125 micron transparent Mylar DuPont sheet) of the transversal sections of those parts had been previously transferred to. Then, all the frames and futtocks were inserted in a «U» section wood keel, through transversal grooves, corresponding exactly to the transversal axis of the feet of each frame. The 3D model was made of medium density polyurethane sheets with the exact thickness of each group of frames and futtocks, and the four faces of each frame were sculpted accurately and finally painted dark brown to suggest old wood.

It was thus unvailed the significance of the first of the three engraved numeral marks; and one of the other two (the «XII» or the «XV») would certainly correspond to the aft loof frame of the ship; the only thing missing was to find what the remaining mark means.

This simple conclusion was the first positive contribution of the Seminar held at Cadiz.

* * *

The second contribution of this Seminar resulted from a fortuitous conversation between the A. and Cemal Pulak, which gave place to two important questions:

- One, formulated by the A., pointed to the resemblance between the internal axial and transversal hull structures of *Ria de Aveiro A* and *Contarina 1* shipwrecks, especially in the keelson zone;
- the other one, by Cemal Pulak, stressed the radical structural, architectural and functional difference between the aft terminal parts of both ships, *Contarina 1* being a round stern ship (Fig. 2.22), using the multi-millennial lateral rudder, while *Ria de Aveiro A* had its stern «like a cog», he concluded[19].

This remark of Cemal Pulak was not only absolutely justified but also extremely rich of significance, due to the implicit suggestion of reconsidering the genealogy of the stern structure of the caravel of the Portuguese *Quattrocento* — this referring to the fundamental question of the transition in Portugal from the use of a round stern, associated with a lateral rudder — or even with an incipient axial one, as McGrail admitted[20] — to the generalized use of an axial rudder fixed to an axial stern. This was, in any case, a fundamental nautical innovation at architectural, structural and functional levels, and particularly decisive to oceanic and transoceanic navigation, especially due to the intense maritime traffic between the northern and southern Europe regions during the

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[19] In fact, Filipe Castro (2012: 28) already had said: «Das cogas, os navios portugueses do século XVI parecem ter herdado os couces (hooks) […]» («the Portuguese ships of the 16th century seem to have inherited the hooks from the cogs […]»). Interestingly enough, this author did not mention the well-known archaeological finds that include preserved heels («couces»), from *Corpo Santo* (ALVES *et al.*, 2001a) and *Ria de Aveiro A*, respectively from the 14th and 15th centuries, but also from *Varadouro*, from the 16th/1st half of the 17th century, still unpublished but exhibited in the Municipal Museum of Esposende.

[20] «Several town seals of the thirteenth and fourteen centuries (for example Elbing, 1242, Wismar, 1256, Poole, 1325) show vessels with centreline rudders; these may best be described as ships as they are clearly decked and no longer open boats. Median rudders are also depicted on the Tournai fonts at Winchester (Fig. 8.18.) and Zedelgem, Bruges, Belgian (FENWICK, 1978: Fig. 8.12b), which are conventionally dated to the late twelfth century. Nevertheless, early fourteenth-century seals of de Faversham (FENWICK, 1978: Fig. 8.32c) and Winchelsea (FENWICK, 1978: Fig. 8, 25, 4) show evidently fair-sized vessels with side rudders which, if not an anachronism, may indicate that during the twelfth/fourteenth century both side and median rudders were used. It may be that, at first, median rudders were used on the curved hull form of vessel (hulc), depicted on the late twelfth-century font and on the cog, rather than the post-Viking development of the Norse tradition (keel)» (MCGRAIL, 1998: 251).

Middle Ages, as well as with Cantabria, Galicia, Portugal, the Al-Andalus, and of course with all Mediterranean areas[21].

* * *

At this point, the A. must evoke here, at first hand, the interest dedicated by his good friend and master, late Octávio Lixa Filgueiras (1922-1996)[22], to the representation in low relief of an old sailing ship on the southern tower of the Cathedral of Oporto (Fig. 2.29), which he identified as a cog, in a short but extremely interesting paper, where he assembled some relevant quotations concerning the relation between cogs and Portugal[23] — a subject that is here brought to the present.

Fig. 2.29. Cog sculpted on the southern tower of the Oporto Cathedral
Source: <http://cidadesurpreendente.blogspot.pt/2010/12/nave-esculpida-numa-torre-da-se-do.html>
[Access on 07/08/2016]

The cog has its archaeo-museologic paradigm in a shipwreck discovered in 1962, during dredges in the estuary of the river Weser, which was baptized as «Bremen cog»[24]. The remain has been exposed since 2000, as an extraordinary masterpiece, in the Deutsches Shiffahrtsmuseum of Bremerhaven (Fig. 2.30), after many years of impregnation by immersion in a water solution of poly-ethylene-glycol (PEG) and structural remounting[25].

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[21] PICARD, 1997a, 1997b.
[22] ALVES, 2009a.
[23] FILGUEIRAS, 1982, 1983.
[24] ELLMERS, 1994.
[25] In 1982 the A. in company of Rui Parreira had the opportunity to catch a glimpse of the «Bremen cog», immersed in its dark bath of PEG solution, during an unforgettable study visit to 43 German archaeological institutions, as guests of the Deutsches Archäologisches Institut.

Fig. 2.30. «Bremen cog» displayed in the Deutsches Shiffahrtsmuseum of Bremerhaven
Source: <http://bertan.gipuzkoakultura.net/ac/accesibilidad.php>. [Access on 16/08/2016]

In a very brief characterization of its structure, the cog is a flat plank bottom and a clinker hull ship (Fig. 2.31), therefore differing from ships of Viking tradition, in which the planking is structured on the basis of a «classical» keel with quadrangular section. The flat bottom planking is composed with symmetrical planks laterally jointed, the axial one being thicker than the others, and in a certain sense representing a «proto--keel»; from the turn of the bilges on the planks are «bitten» in both sides by the upper ones, as can be seen in the sections of the cogs of Bremen, Kollerup, Kolding and Vejby (Fig. 2.32). As the «Bremen cog» shows, the cogs also had strong transversal beams that consolidated the hull by penetrating it transversally down to the external surface. They also have characteristic strong bars or posts, fore[26] and aft, here constituting the terminal part of a heel with a terminal angular skeg, serving for the protection of the rudders base, and also corresponding to the extremity of the keel, sculpted in the heel.

[26] ESPARTEIRO, 1974: 25.

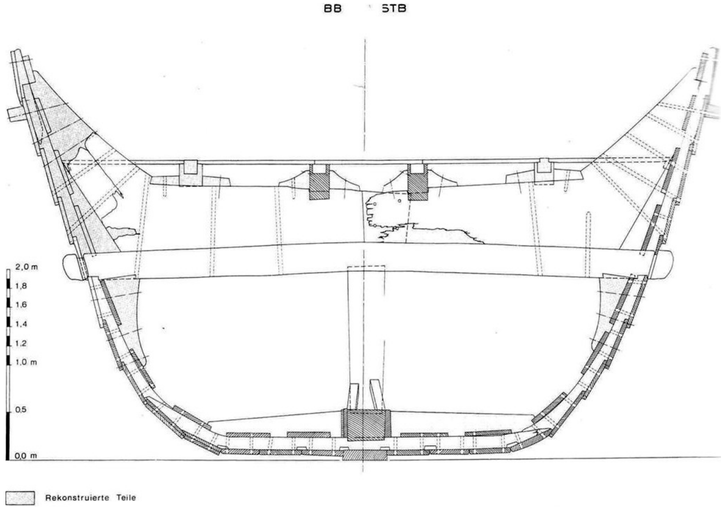

Fig. 2.31. Central section of the «Bremen cog»
Source: CRUMLIN-PEDERSEN, 2000: 232, Fig. 3 ff. LAHN, 1992

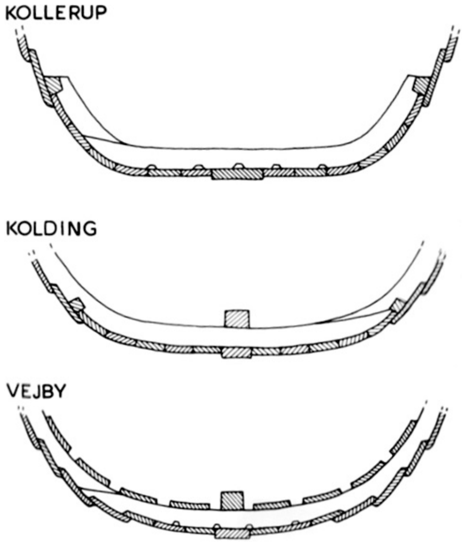

Fig. 2.32. Central sections of the cogs from Kollerup, Kolding and Vejby
Source: CRUMLIN-PEDERSEN, 2000: 234, Fig. 5 ff. CRUMLIN-PEDERSEN, 1979

About the place where the cog had its origin, Ole Crumlin-Pedersen[27] concludes: «The evidence from the cog finds known so far points in another direction for the early history of the seagoing cog of the 12th-14th centuries. It points to the northernmost Frisian area between the river Eider and Ribe as having the best potentials to be a

[27] CRUMLIN-PEDERSEN, 2000: 238-239.

primary area for the modification of a hypothetical older 'proto-cog' type, used for navigation on inland and tidal waters, into a seagoing cog capable of circumnavigating Cape Skagen/The Skaw […]»; and, according to this author, the generalization of the use of the «classical» stern (heel/*couce de popa*) would have occurred in the north of Europe, fundamentally in the geographic space of the Hanseatic League, and specifically in its southeast — the Frisian area (Fig. 2.33).

Fig. 2.33. Jutland map with the Frisian region and the Skagen cape pointed out
Source: CRUMLIN-PEDERSEN, 2000: 240, Fig. 8

2. DATED REFERENCES CONCERNING THE SUBJECT[28]

Late 10th century–mid-12th Century[29] — Radiocarbon date of a clinker hull frame (Fig. 2.34) recovered in the 70s by a retro-excavator during water caption works in the plain (*várzea*) of Alfeizerão (centre-littoral of Portugal). This plain was originally a lagoon progressively and finally completely silted in the 16th century.

[28] Selection in a very preliminary approach of the theme.
[29] *Intersections*: 1001, 1012, 1017 cal DC; *Intervals*: 1 *sigma*: 989-1025 cal DC; 2 *sigma*: 971-1151 cal DC (ICEN-123).

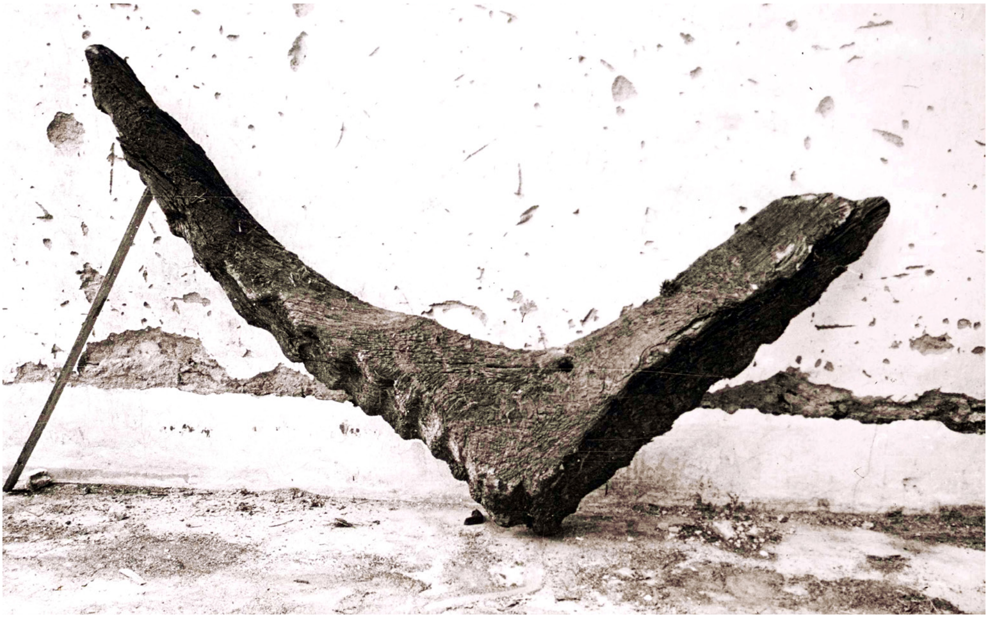

Fig. 2.34. Clinker hull frame found in the 70s near Alfeizerão
Source: Eng.º geólog. Teixeira Pinto (de Alfeizerão)

12th century — (Referring the «proto-cog» — the hulc): «dominant type of ship in the Atlantic, from Spain till Livonia, starting at the first decades of 12th century»[30].

1147 — «The earliest recorded use of the word cog for seagoing ships seems to have designated two of the Flemish vessels of the Second Crusade in 1147»[31]. This date corresponds to the conquest of Lisbon to the Muslims by the first King of Portugal, Afonso Henriques, with the help of a fleet of crusades from the north of Europe in their way to the Holy Land.

1153 — The first Portuguese King Afonso Henriques donated to the Order of Cister the *Coutos* of Alcobaça, which were, until the 16th century, a vast, rich, and navigable lagoon area, with several harbours, developing an intense maritime trade with the north of Europe, namely with the Hanseatic League[32].

1159 — Foundation date of Lübeck and the Hanseatic League[33].

Late 12th century (1180?) — «Scenes from the life of St. Nicolas on the font in Winchester Cathedral» (Fig. 2.35). «The ship is believed to represent a hulc»[34], a typical round stern ship.

[30] MARQUES, 1959: 73-74.
[31] BILL, 1997: 158 *apud* CRUMLIN-PEDERSEN, 2000: 238.
[32] MARQUES, 1959.
[33] ELLMERS, 1994: 37.
[34] MCGRAIL, 1998: 118.

Fig. 2.35. Low relief band of the baptistery in the Winchester Cathedral
Source: MCGRAIL, 1998: 118, Fig. 8.18

1210 — «[…] The King of England himself had acquired a cog by 1210. Some of the crusaders who travelled from the North Sea to the Holy Land along the western coast of Europe made their journey by cog, so cogs were observed in the Bay of Biscay and in the Mediterranean»[35].

1224 — Town seal of Lübeck (Fig. 2.36): «It is a reasonable assumption that each town depicting a cog on its seal showed the latest stage in the development of ship construction. However, when Lübeckers depicted a cog with firrer in their first seal of 1224, that type of side rudder had already been replaced by the stern rudder, shown on the seals of all the other large Hanseatic towns»[36].

Fig. 2.36. Lübeck town seal (1224)
Source: CRUMLIN-PEDERSEN, 2000: 233 («after Ewe, 1972»)

1241 — «in 1241 […] a cog is mentioned with a cargo capacity of about 240 tons. The Bremen cog from 1380 with a capacity of about 80 tons is just a small version of the type»[37].

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[35] ELLMERS, 1994: 39.
[36] ELLMERS, 1994: 37.
[37] ELLMERS, 1994: 38.

1243 — «The oldest town seal […] with additional external stem and sternposts is that of Stavoren in the Netherlands.»[38].

1256 — «[…] In the Baltic it is that of Wismar […]»[39].

1297 — Reference to the «gentes que andam nas Naes e nos Baixees e nos Aloques e nas Cocas de ffonte Rabia de Sam Sanaschãão/de verm éo de Quitaría/de Crasto/de Laredo/de Santander/e de abelhes/e da Crunha que ora estam no Porto da dita Cidade de Lixbba […]»[40], «I did not find, however, any allusion to cogs run by Portuguese. Should be concluded that they (the cogs) weren't used among us?»[41].

1299 — Town seal of Danzig (Fig. 2.37) representing a cog with its stern rudder[42].

Fig. 2.37. Danzig town seal (1299)
Source: ELLMERS, 1994: 41

1304 — «In the summer of 1304 the Florentine chronicler Giovanni Villani wrote: "Then the pirates of Bayonne, of Gascony, came in their ships, which they called cogs, through the Straits of Gibraltar and into the Mediterranean, and caused much damage. Since then people from Genoa, Venice, Catalonia have also started using cogs, and have given up sailing in their large ships, as the cogs are cheaper to build, and more seaworthy. There has thus been a major change in the types of vessel we use in our seafaring"»[43].

1329 — Town seal of Stralsund (Fig. 2.38) representing a cog with its stern rudder[44].

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[38] ELLMERS, 1994: 37.
[39] ELLMERS, 1994: 37.
[40] PICO, [s.d.]: 90.
[41] PICO, [s.d.]: 91.
[42] ELLMERS, 1994: 37. The following reference (1333/34) gives an answer to this question.
[43] ELLMERS, 1994: 39.
[44] ELLMERS, 1994: 29.

Fig. 2.38. Stralsund town seal (1329)
Source: ELLMERS, 1994: 29

1334 — «in the year of 1333/34 occurred in the reign of Aragon an important rise of cereal prices. To supply the city of Barcelona the Municipal Consellers gave the order to their chief of fleet, Galferán Marquet, to seize all ships with a wheat cargo. In June of 1334 were seized by the mentioned Marquet 6 portuguese cocas transporting wheat to Portugal; this provoked a serial of complains of the Portuguese King and of the municipal authorities of Lisbon adressed to Alfonso El Benigno and the Consellers of Barcelona [...]»[45].

1336 — «The clincker construction is pictured in several representations of ships of the 14th century, as in the memorial stone of Bica do Andaluz, (1336)»[46] (Fig. 2.39). This stone includes at the right of the bas-relief an engraved inscription (not always reproduced together), which indicates the era of 1374[47].

Fig. 2.39. Representation of a hulk on the left side of the memorial stone at Bica do Andaluz in Lisbon; part of the inscription appears to the right
Source: <https://www.pinterest.pt/pin/46302702402862754>. [Access on 18/08/2016]

[45] FILGUEIRAS, 1982: note 27, 117; CALLICÓ, 1968.
[46] CASTRO, 2012: 26 *apud* FONSECA, 1935: 15.
[47] This date refers to the Hispanic Era which in Portugal had been in use until 1422. In the Christian Era (which began 38 years later) it corresponds to the year of 1336, VITERBO, 1865: II, 289-292.

The clincker ship illustrated at *Bica do Andaluz*, with its round stern and lateral rudder, is not a cog but a hulc, as represented on the town seal of Lübeck. However, in this case the symmetrical drakkar protomos of Scandinavian tradition were replaced by the traditional pair of crows turned inside, veiling the deceased Saint Vincent, in accordance with the Christian funerary liturgy and Lisbon heraldic iconography, referring to the transfer of the Saint's body from Algarve (south of Portugal) to Lisbon.

1360 — «Although not having the central rudder represented, a typical cog of the 14th century is sculpted in the memorial stone of the fountain of Arroios (1360, era 1398), with the characteristic straight stem and stern, clinker sides and a single mast lifting a single square sail»[48] (Fig. 2.40). However, a more careful observation reveals that instead of a typical straight stempost, the Arroios stem is progressively curbed, approaching the typical profile of the 14th century Bayonnese cog[49], and of the early 15th century model known as *coca of Mataró*, nowadays in the Maritime Museum Prins Hendrik of Rotterdam.

Fig. 2.40. Bica do Andaluz memorial stone
Source: <http://lisboahojeeontem.blogspot.pt/2012/11/chafariz-de-arroios.html>. [Access on 18/08/2016]

In what concerns the representation of the Arroios ship hull, which looks like a brick wall, the A. of the present paper considers that it is so schematic and rough that it does not allow us to interpret it as a carvel or a clinker-built (even if in this case,

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[48] CASTRO, 2012: 28 *apud* FONSECA, 1935: 17.

[49] ZWICK, 2016: 655, reproduces two images of what is supposed to be a Bayonnese cog, taken from the site http://www.navalmodel.es/Naval_Model/La_afilada_pluma_de_Lizarraga.html. The upper-left image is a photo of the medallion of «a vault in Bayonne Cathedral, from the late 14th century», whose central subject (apparently in painted relief) is a supposed Bayonnese cog with its typical straight stern and round stem, showing a clear clinker planking alternately represented in yellow and brown. The right-down one shows a beautiful conjectural model of a Bayonnese cog, referred to as «trabajo de Miguel Laburu, ampliado y actualizado por J. M. Lizarraga. Fotos J. M. Lizarraga». Curiously, this model presents a stern/keel skeg (corresponding to the original representation?).

theoretically, the clinker system could be compatible with any dimensional planking constraint, obviously depending on the framing spacing). Indeed, it should always be kept in mind what Sarah C. Humphreys wrote in conclusion, regarding any iconographic interpretation: «[…]. One should always remember, in interpreting iconographic evidence, the rebuke of Matisse to a visitor who was criticizing one of his nudes, for lack of realism: 'Madame, you seem to be making a mistake. What you are looking at is not a woman: it is a picture'»[50].

1365 — Town seal of Kiel (Fig. 2.41) representing a cog with its stern rudder[51].

Fig. 2.41. Kiel town seal (1365)
Source: ELLMERS, 1994: 38

1380 — Conventional date of the Bremen cog remains discovered in October 1962 Dendrochronology dates point to 1378 DC.

1430 — «in 1430 Lisbon and Danzig have established permanent commercial relations […]»[52].

CONCLUSION

The *Ria de Aveiro A* ship, in spite of being an incomplete find, constitutes so far the closest and sole example in the world of what might have been an early Portuguese caravel, whose origin and development should have occurred in any of the Portuguese coastal zones, either estuary or lagoon, or any other rich in maritime mixed traditions, Atlantic and Mediterranean — especially in the art and science of shipbuilding. The use of ships with a central sternpost and an axial rudder as well as its introduction and diffusion in Atlantic Europe constitute, no doubt, a topic of major significance, in the

[50] HUMPHREYS, 1978: 79; CASTRO, 2012: 26 *apud* ALBUQUERQUE, 1994: 484.
[51] ELLMERS, 1994: 38.
[52] CASTRO, 2012: 26 *apud* ALBUQUERQUE, 1994: 484.

context of World History, for the history of techniques, naval architecture and navigation. Indeed, the Hanseatic cog and the Portuguese caravel of *Quattrocento* represent two of the most paradigmatic examples — oceanic and transoceanic, respectively — in late Medieval Europe; the heel of the cog having or not definitely influenced the caravel.

ADDENDUM

The structural remains of the mid-15th-century shipwreck *Ria de Aveiro A* make it, until now, the closest contemporary example of what would have been a caravel of the African coast Portuguese exploration of the 15th century. They are comprised of hull framing and planking elements, parts of the keel, the heel and the keelson, as well as a significant part of the cargo, mainly composed by local common earthenware of large European and even transoceanic diffusion.

Today, twenty years after the beginning of the archaeological excavation in 1996, 17 years after a careful underwater dismantling of the structural elements of the ship in 1999, followed by the beginning of their laboratorial desalination, and 13 years after the beginning of their conservation treatment by impregnation with PEG in water solution (heated, filtered and circulating under monitored conditions) (Figs. 2.42 and 2.43), nothing can guarantee those remains did not undergo an irreversible process of degradation.

Fig. 2.42. Representation of a cog on the memorial stone at the Chafariz de Arroios, Lisbon
Source: Francisco Alves

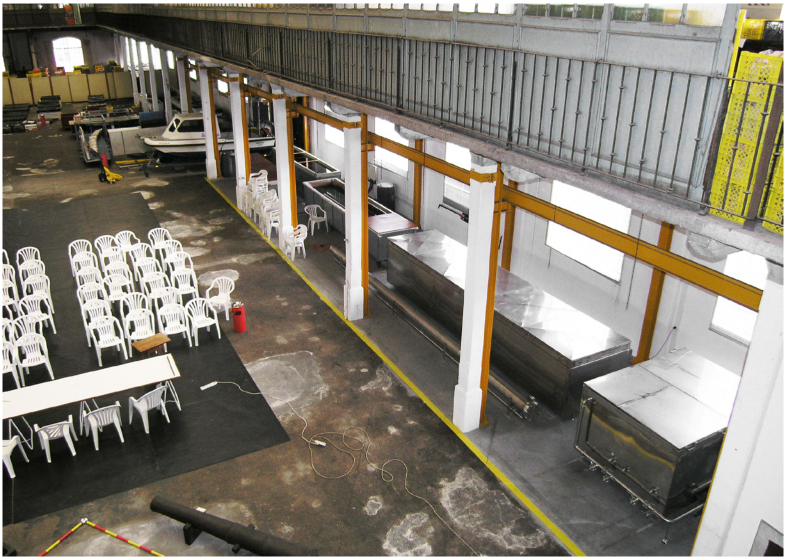

Fig. 2.43. View of the conservation laboratory of the National Centre for Nautical and Underwater Archaeology in Belém, Lisbon, dismantled in 2010, and not remounted in the new CNANS facilities in the new intermunicipal Central Market of the Lisbon Region, at Loures. The two large tanks (of steel 316) were used for the treatment with PEG of the remains from the *Ria de Aveiro A* shipwreck; behind them, the polypropylene tanks for impregnation also with polyethylene glycol of the Medieval dugouts 1 and 2 from River Lima
Source: Francisco Alves

Fig. 2.44. Steel shelf-stand, hanging from a crane, for the immersion of the wooden structural pieces of RAVA. It could be moved, longitudinally and transversally, over the tanks' area, by means of a «chariot» with manual control working on rails supported by an iron structure composed with H-shaped girders, anchored to the concrete pillars of the building
Source: Francisco Alves

Effectively, the laboratorial conservation process was interrupted in 2010, due to the transfer of the Service of Nautical and Archaeological Archaeology (CNANS, Belém, Lisbon) to a warehouse in the near municipality of Loures. The transfer was not followed by the remounting of any of the devices indispensable to the safety of the structural wooden hull pieces. Even the periodical biological control of the immerged wood was therefore interrupted, with the inevitable risk of degradation of those precious relics.

It must be remembered that conservation treatments (even the preventive ones), on a large scale, of archaeological waterlogged large pieces of wood was introduced for the first time in Portugal under the initiative of CNANS (as part of Portuguese Institute of Archaeology [IPA, 1997-2007]) that, for this purpose, had a conservator following a six-month stage in the Arc-Nucléart of Grenoble, one of the world's most reputed specialized laboratories in conservation of ancient waterlogged woods. However, in 2006, facing the impending official decision to reduce the staff of CNANS, this specialized conservator accepted the invitation to integrate the team of the conservation project *Monitor* (an ironclad dating from the American Civil War times), promoted by NOHA, in association with the Mariner's Museum and Park (Newport News, Virginia).

This situation, promoted and/or tolerated by all Portuguese Governments since 1997, foretold an intolerable calamity to the Portuguese underwater cultural heritage[53], and representing an inadmissible disrespect of the 2001 UNESCO Convention on the Protection of the Underwater Cultural Heritage ratified by Portugal in 2006 — following the unanimous and effusive vote of all members of the Portuguese Parliament — represented effectively the progressive disqualification and the final destruction of CNANS in its original version.

EDITED SOURCES

ALBUQUERQUE, Luís (1994) — *Dicionário de História dos Descobrimentos Portugueses*. Lisbon: Editorial Caminho.

ALVES, Francisco (1993-1994) — *Por mosaicos nunca dantes navegados. Sobre a iconografia da nave de Ulisses do mosaico de Santa Vitória do Ameixial*. «Conimbriga», vol. 32-33, p. 247-261.

_____ (1998) — *Archaeology of a shipwreck*. In AFONSO, Simonetta Luz, *ed.* — *Nossa Senhora dos Mártires: The Last Voyage*. Lisbon: Pavillion of Portugal in the Expo'98; Verbo, p. 182-215.

_____ (2009a) — *A arqueologia subaquática em Portugal – o legado de Octávio Lixa Filgueiras*. In GARRIDO, A.; ALVES, F., *coord.* — *Octávio Lixa Filgueiras – Arquitecto de Culturas Marítimas*. Lisbon: Âncora Editora, p. 125-134.

_____ (2009b) — *O navio português do século XVI de Oranjemund, Namíbia — Relatório das missões realizadas pela equipa portuguesa em 2008 e 2009*. In *Trabalhos da DANS, 45*. Lisbon: DANS-IGESPAR.

_____ (2011) — *The 16th century Portuguese shipwreck of Oranjemund, Namibia – Report on the missions carried out by the Portuguese team in 2008 and 2009*. In *Trabalhos da DANS*, 45. Lisbon: DANS-IGESPAR.

[53] Calamity, not only in what concerns the structural remains of *Ria de Aveiro A* shipwreck, but also the ultra-rare proto-roman dugouts, 4 and 5 of Lima river (Lanheses), (ALVES; RIETH, 2007; RIETH, 2009) — which are still immersed in basic preservation since 2003, but should already be entered in PEG impregnation treatment.

_____ (2013) — *O salvamento dos vestígios estruturais do navio português do século XVI de Oranjemund, Namíbia, 2008-2009 – um exemplo de cooperação entre um estado «costeiro» e um estado «de bandeira»*. «Revista Tecnologia e Ambiente, Dossiê IX Jornadas de Arqueologia Iberoamericana e I Jornada de Arqueologia Transatlântica», vol. 19, n.º 1, p. 248-261.

ALVES, Francisco *et al.* (1998) — *A cerâmica dos destroços do navio dos meados do século XV Ria de Aveiro A e da zona Ria de Aveiro B. Aproximação tipológica preliminar.* In *Actas das 2.as Jornadas de Cerâmica Medieval e Pós-Medieval*. Tondela: Câmara Municipal de Tondela, p. 185-210.

_____ (2001a) — *The hull remains of Ria de Aveiro A, a mid-15th century shipwreck from Portugal: a preliminary analysis*. In ALVES, Francisco, *ed.* — *Proceedings – International Symposium on Archaeology of Medieval and Modern Ships of Iberian-Atlantic Tradition — Hull remains, manuscripts and ethnographic sources: a comparative approach*. Lisboa: IPA, p. 317-345.

_____ (2001b) — *Ria de Aveiro A: a shipwreck from Portugal dating to the mid-15th century; a preliminary report*. «International Journal of Nautical Archaeology and Underwater Exploration», vol. 30, n.º 1, p. 2-36.

_____ (2001c) — *The remains of a 14th-century shipwreck at Corpo Santo, and of a shipyard at Praça do Município, Lisbon, Portugal*. In ALVES, Francisco, *ed.* — *Proceedings International Symposium on Archaeology of Medieval and Modern Ships of Iberian-Atlantic Tradition — Hull remains, manuscripts and ethnographic sources: a comparative approach*. Lisbon: IPA, p. 405-426.

BARATA, João da Gama Pimentel, *ed.* (1996) — *João Baptista Lavanha. Livro Primeiro da Architectura Naval*. Fac-símile. Lisbon: Academia de Marinha.

BILL, Jan *et al.* (1997) — *Fra stammebåd til skib*. In *Dansk søfarts historie 1. Indtil 1588*. København: [s.n.].

BONINO, Marco (1978) — *Lateen-rigged medieval ships. New evidence from wrecks in the Po Delta (Italy) and notes on pictorial and other documents*. «International Journal of Nautical Archaeology and Underwater Exploration», vol. 7, n.º 1, p. 9-28.

CALLICÓ, Jaume Sobrequés (1968) — *Sequestro de naves portuguesas en Cataluña (1334).* In *Congresso Luso-Espanhol de Estudos Medievais (Oporto, 18 to 23 of June, XI Centenário da Presúria de Portugale por Vímara Peres)*. Porto: Câmara Municipal.

CARVALHO, Patrícia; BETTENCOURT, José António (2012) — *De Aveiro para as margens do Atlântico: a carga do navio Ria de Aveiro A e a circulação de cerâmica na Época Moderna*. In TEIXEIRA, André; BETTENCOURT, José António, *coord.* — *Velhos e Novos Mundos – Estudos de Arqueologia Moderna*. Lisbon: CHAM, vol. 2, p. 733-746.

CASTRO, Filipe (2001) — *A Portuguese Indiaman at the Mouth of the Tagus River*. Texas: Texas A&M University. PhD dissertation.

_____ (2012) — *Os navios dos séculos XVI e XVII: linhas gerais de evolução, unidades de medida e arqueio*. In DOMINGUES, Francisco Contente, *coord.* — *História da Marinha Portuguesa – Navios, Marinheiros e Arte de Navegar – 1500-1668*. Lisbon: Academia de Marinha, p. 17-45.

CRUMLIN-PEDERSEN, Ole (2000) — *To be or not to be a a cog: the Bremen Cog in perspective*. «International Journal of Nautical Archaeology and Underwater Exploration», vol. 29, n.º 2, p. 230-246.

ELLMERS, Detlev (1994) — *The cog as a cargo carrier*. In GARDINER, R.; UNGER, R., *ed.* — *Cogs, Caravels and Galleons, The Sailing Ship 1000-1650*. London: Conway's History of the Ship, p. 29-46.

ESPARTEIRO, António Marques (1974) — *Dictionary of naval terms (English-Portuguese)*. Lisbon: Centro de Estudos de Marinha.

EWE, H. (1972) — Schiffe auf Siegeln. [S.l.]: [s.n.].

FENWICK, Valerie (1978) — *Graveney boat*. «Oxford: NMM Archaeological», series 3, BAR 53.

FILGUEIRAS, Octávio Lixa (1982) — *A nave esculpida numa torre da Sé do Porto. Ensaio de identificação*. «Arqueologia», vol. 6, p. 112-117.

FONSECA, Henrique Quirino da (1935) — *Memórias e conferências sobre história e arqueologia*. Lisbon: Serviços Industriais da C. M. L.

HUMPHREYS, Sarah C. (1978) — *Artists' mistakes*. «International Journal of Nautical Archaeology and Underwater Exploration», vol. 7, n.º 1, p. 78-79.

MARQUES, António H. R. Oliveira (1959) — *Hansa e Portugal na Idade Média*. Barcarena: Editorial Presença.

MCGRAIL, Seán (1998) — *Ancient Boats in North-West Europe — The Archaeology of Water Transport to AD 1500*. London; New York: Longman Archaeology Series.

MENDONÇA, Henrique Lopes, *ed*. (1991) — *Fernando Oliveira, O Livro da Fabrica das Naos*. Fac-símile. Lisbon: Academia de Marinha.

NIETO, Xavier; RAURICH, Xim, *coord*. (1998) — *Excavacions arqueològiques subaquàtiques a Cala Culip, 2. Culip VI*. Girona: Museu d'Arqueologia de Catalunya-Centre d'Arqueologia Subaquática de Catalunya.

OERTLING, Thomas (2001) — *The concept of Atlantic vessel*. In ALVES, Francisco, *ed*. — *Proceedings International Symposium on Archaeology of Medieval and Modern Ships of Iberian-Atlantic Tradition — Hull remains, manuscripts and ethnographic sources: a comparative approach*. Lisbon: IPA, p. 233-240.

PICARD, Christophe (1997a) — *La mer et les musulmans d'Occident au Moyen Âge – VIII^e^-XIII^e^ siècle*. Vendôme: PUF.

_____ (1997b) — *L'océan Atlantique musulman: De la conquête arabe a l'époque almohade: navigation et mise en valeur des côtes d'al-Andalus et du Maghreb occidental (Portugal-Espagne-Maroc)*. Paris: Editions UNESCO.

PICO, Maria Alexandra Carbonell [s.d.] — *A terminologia naval portuguesa anterior a 1640*. Lisbon: Sociedade de Língua Portuguesa.

RODRIGUES, Paulo *et al*. (2001) — *L'Épave d'un navire de la deuxième moitié du XVème siècle/début du XVIème, trouvé au Cais do Sodré (Lisbonne). Note préliminaire»*. In ALVES, Francisco, *ed*. — *Proceedings International Symposium on Archaeology of Medieval and Modern Ships of Iberian-Atlantic Tradition — Hull remains, manuscripts and ethnographic sources: a comparative approach*. Lisbon: IPA, p. 347-380.

VITERBO, Joaquim de Santa Rosa de (1865) — *Elucidário das palavras, termos e frases que em Portugal antigamente se usaram e que hoje regularmente se ignoram…* Lisbon: A. J. Fernandes Lopes.

ZWICK, Daniel (2016) — *Bayonese cogs, Genoese carracks, English dromons and Iberian carvels: Tracing technology transfer in medieval Atlantic shipbuilding*. «ITSAS Memoria. Revista de Estudios Marítimos del País Vasco», vol. 8, p. 647-680.

WOODEN SHIPBUILDING TECHNIQUES AT VILA DO CONDE'S SHIPYARDS

ANTÓNIO JOSÉ CARMO

INTRODUCTION

This presentation was conceived based on project elements and the traditional techniques used in the mould loft, for the last wooden vessel built in Portugal for inshore fishing, at the Samuel e Filhos Lda. Shipyard in Azurara, Vila do Conde.

Identification of the ship
Name: Novo Rosa Clara
Construction started: April 2005, ended: July 2007
Length: 18m; Beam: 5.2m; Moulded depth: 2.25m

1. THE LAST KEEPERS OF KNOWLEDGE

While it is uncertain when exactly the oldest shipbuilders began using designs with the intent of both planning the construction of ships and record information and techniques for future generations, it is generally agreed that it must have emerged during the first millennium of the Current Era, motivated by the development of new techniques pertaining to construction.

The oldest elements represented in drawings, dating from sometime between the turn of the sixteenth century and the dawn of the seventeenth century, allow us to ascertain the type of architecture and methods employed in the construction of the ships in the aforementioned period.

The contents of Fernando de Oliveira's (*Ars nautica*, 1570, and *Livro da Fabrica das naos*, 1580), João Baptista de Lavanha's (*Livro Primeiro da Arquitetura Naval, circa* 1600) and Manuel Fernandes' (*Livro de Traças de Carpintaria*, 1616) opuses not only demonstrate how advanced shipbuilding was at the time but also evidence that, at its core, the aforementioned craft did not undergo any major changes during these last 400 years.

João Baptista de Lavanha greatly emphasises the role of the naval architect within the shipyard, the extensive knowledge required, the study and planning that preceded the construction processes, from the design to the resources to be employed, the cost of the endeavour, the choosing of the woods to be used, the shapes (moulds)… The chronicler asserted that the success of all the work hinged on this knowledge.

Naval architecture and all the construction process appear as well consolidated fields in the sixteenth century and kept evolving in many ways up until the present day. However, some practices remained unchanged over the centuries. One example is the use of the *graminho* technique for the creation of the moulds (a process of moulding for the narrowing and the rising of the frames), that has seen little to no evolution since the seventeenth century.

This technique is still used nowadays, especially in smallerscale shipyards, where empirical knowledge plays a significant role in the shipbuilding process.

On the other hand, regarding larger-scale shipyards, where teams of artisans of various crafts work together in the construction of large vessels, we can see the use of more complex techniques. On these spaces, the shipbuilding process is preceded by a large number of studies, execution of designs, models and moulds. All is meticulously planned through designs and calculations beforehand; these plans are brought to the mould loft and only then is the execution of moulds done. Hence, the role of the naval architect is one of pivotal importance in the whole shipbuilding process.

The mould loft is yet another decisive element, since it is the cornerstone of all the shipyard. From this room and the moulds that come out from there depends its success. When the whole-moulding is well executed, all the framework turns out perfect. All the parts fit flawlessly, thereby reducing production time by a large amount.

Since this technique was a true trade secret, and also due to its complexity, only a few individuals were privy to it. Fernando de Oliveira, in 1580, mentioned the matter in the following manner: «[…] In which part the masters of this work are granted free reign to demonstrate their skills: & and, if they are indeed able artisans, their work shall demonstrate it. This is what they hide, & keep for themselves, & are in this so stingy, so much so that they do not want to teach their craft even to their own children»[1]. This was one of the best-kept secrets by the master builders in the sixteenth century and, without a doubt, one of the reasons behind the Portuguese Crown's dominion over the seas.

[1] OLIVEIRA, 1995: 105.

Since the Late Middle Ages up until the current day, Vila do Conde has always distinguished itself as one of the centres of wooden shipbuilding; its shipyards were always a cut above the rest. The refined construction technique of its carpenters and the knowledge in lofting methods of its masters and designers contributed to unique constructive processes. Vila do Conde's shipbuilders were the only craftsmen in the world to master the technique of designing the moulding of all the framework in only one mould.

Even after 10 years since the construction of the last wooden boat, this secret is still well kept in Vila do Conde.

Next, we will show the process of the mould lofting, wood shaping, counter-drawing (*contralinhar* — drawing the other side of the wooden part) and the frame futtocks connection of said boat. We will discuss the remaining construction process, which is the allocation of frames, keel, stem, sternposts, stern panel, and all that remains to conclude the building of the vessel in a future paper.

2. THE MOULD LOFT

2.1. Designs to Use

The complete project of a wooden vessel for inshore fishing is itself the embodiment of the large empirical and scientific knowledge, accumulated and passed on within its shipyard. Its «architect» is a profoundly knowledgeable expert in all the stages that make up this complex process.

The geometrical plane and the cut-to-length design are, among others, elements used in the construction of this kind of ship.

The geometrical plane of the hull planking exterior (Fig. 3.1) has as objectives the ascertaining the volumetry of the ship, make the graphics of straight or titled careens, calculate the careen and gravity centres, among other calculations. This design will later be passed on to the mould loft.

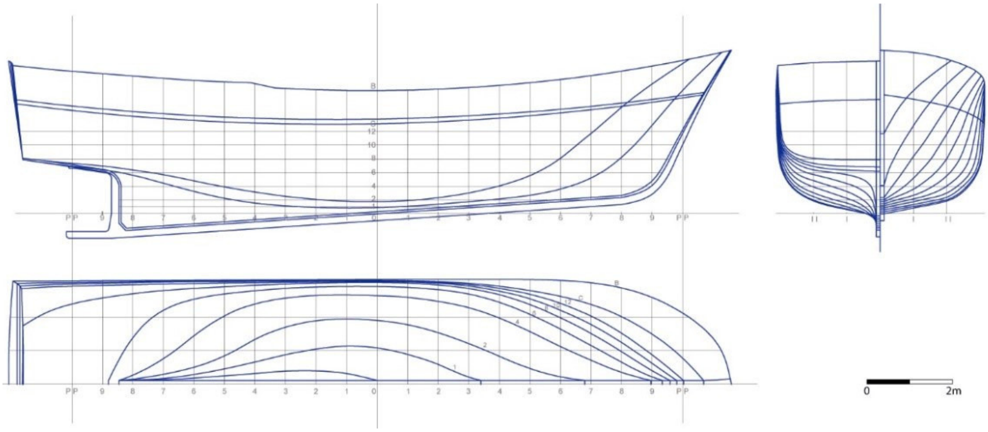

Fig. 3.1. Geometrical plane of the hull planking exterior
Source: António Carmo

The cut-to-length design, scale of 1/25 (Fig. 3.2), defines the structure and architecture of the vessel. This is also essential to obtain structural informations of the hull.

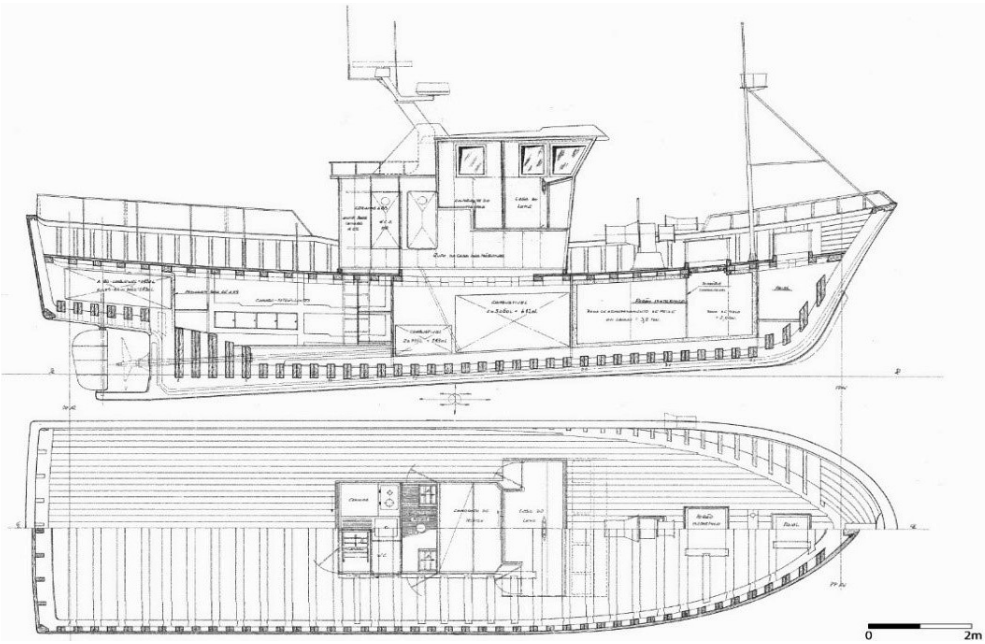

Fig. 3.2. Cut-to-length design
Source: António Carmo

2.2. Designing the Full-Scale Geometrical Plane on the Mould Loft's Floor

The whole lofting process will be developed based on the design of the hull planking exterior's geometrical plane (Fig. 3.1). This will have to be drawn — the drawing being a life-size replica —, to then be used to ascertain, with the help of a scale, all the required dimensions. On the wooden-coated floor are drawn longitudinal, horizontal and transversal planes.

Using carpenter's pencil, wooden sticks, set squares and a chalk line tool, splines (long and thin wooden sticks, suited for drawing curves), the entirety of the geometrical plane is designed, starting with the straight lines:

- water lines (from 0 to 12);
- perpendicular lines of the bow, the stern and in the middle;
- geometrical plane frames, dividing the design into 20 tranversal sections (from 1 to 9 for the bow and from 1 to 9 for the stern);
- longitudinal lines, named *linhas do alto* I and II.

Next, all curved lines are drawn. Splines are used for this purpose. These must be larger and thicker for lines with less curvature, and narrower and thinner for more accentuated curves. All splines must have one end narrower than the other, the narrower side being the one used to draw the more curved section. After the designing process is complete, the intersections between the three planes are verified, and, if necessary, they are corrected.

2.3. Procedure of passing from the hull planking exterior's geometrical plane to the framework

This procedure is required to obtain the geometrical plane in the framework (construction frames' lines). We can see on Fig. 3.3, highlighted in blue, the transversal sections of the geometrical plane of the hull planking's exterior, and in red the same transversal sections (frame's geometrical plane), now inside the hull planking, in other words, in the framework.

This method consists of drawing lines that run parallel to these sections, reducing the hull planking's thickness. This process can also be done with the help of «balance lines» (we will discuss the nature and function of these «balance lines» further on). However, this procedure, albeit more rigorous, is also more complex.

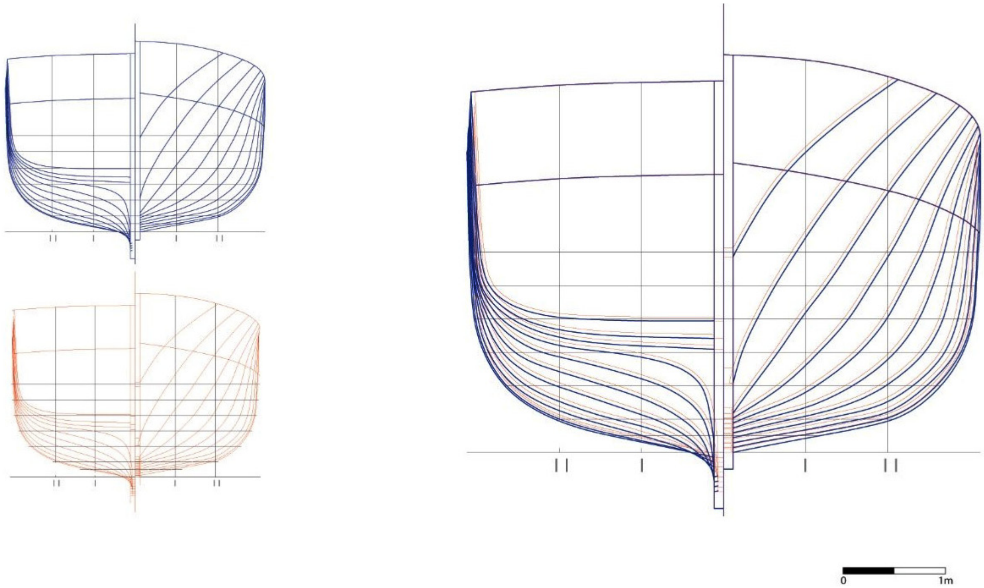

Fig. 3.3. Passing from the geometrical plane of the hull planking's exterior to the framework
Source: António Carmo

2.4. Division and Marking on the 40 Construction Frames (Frame Lines)

With the geometrical plane's frames drawn in the framework, we will now turn to the process of transposing the half-beams to the horizontal plane, the drawing of water lines, numbered from 1 to 12, C and B (Fig. 3.4), now in the framework.

Next, we divide and mark the 40 construction frames (Fig. 3.4, red lines from 01 to 40 on the longitudinal, horizontal and transversal planes).

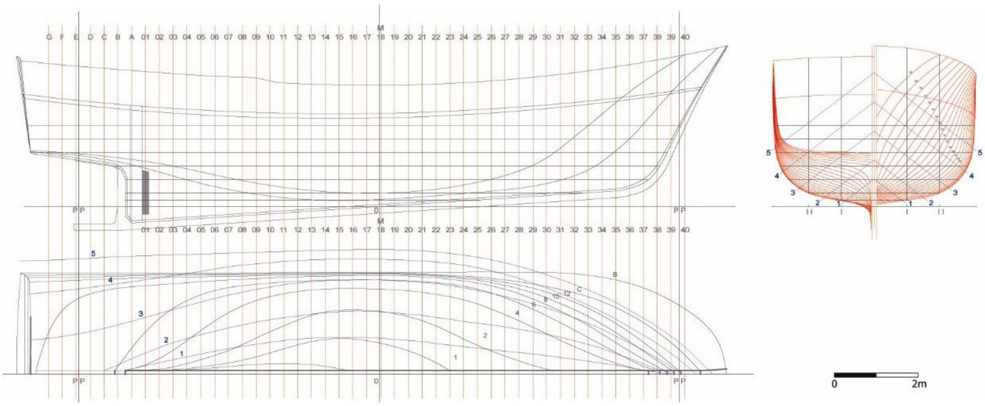

Fig. 3.4. Division and marking of the 40 frame lines
Source: António Carmo

The first frame line to be marked is number 01 (red 01 line on the longitudinal plane), which is leaning on the internal sternpost. In this regard, we firstly mark the sternpost in the design positions, in this case 0.32m, and the internal sternpost, 0.30m (highlighted in blue in Fig. 3.4), from the keel to the deck line. In the same figure we depict frame 01, in its «full» position.

As the frames are doubled, we mark it leaning to the internal sternpost forwards, the size of half of the frame, in this case 0.085m. This line defines exactly the centre lines of frame 01. Based on the markings of frame 01, all others are marked, up until the 40th one, along the longitudinal and horizontal design, maintaining an equal distance between them, which we call *gálimo*, and which is, in this case, 0.30m. In the same figure 3.4, on the right side, highlighted in red, all frame lines are drawn, in the transversal sections' plane.

2.5. The Process of Obtaining the Plane of the Frames' Transversal Sections

Using a wooden stick, we place it on the frame's lines in the horizontal plane and we mark all the intersection points in each water line and from frame line to frame line (Fig. 3.5, lefthand side). Next, all those points are transposed to the transversal sections' plane, and, by joining them with the help of a spline, we get the shape of the frames' lines (Fig. 3.5, righthand side).

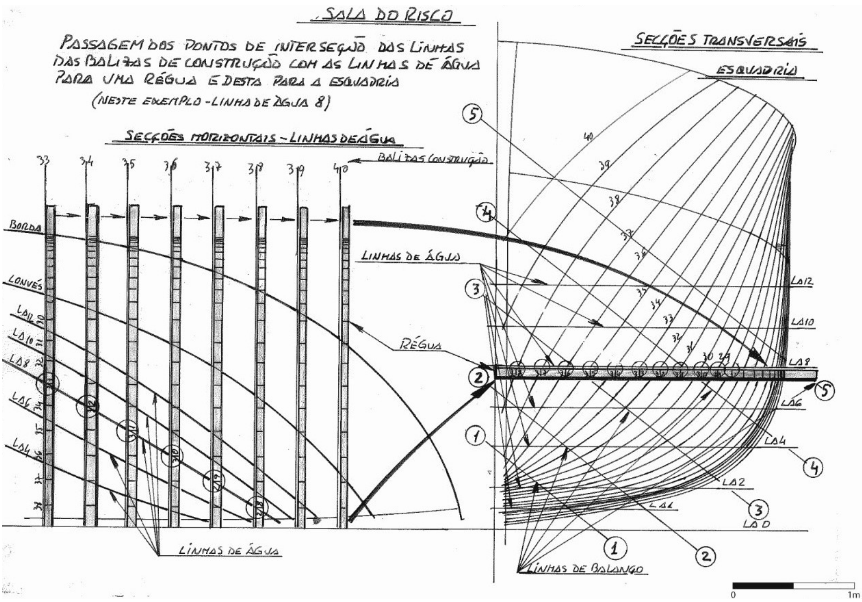

Fig. 3.5. The process of obtaining the plane of transversal sections
Source: António Carmo

2.6. Horizontal Projection of Balance Lines

In Fig. 3.4, righthand side, we can also see, drawn on the transversal sections' plane and over the frame lines, some tilted planes, highlighted in blue, named «balance lines», numbered 1 to 5, and which are transposed to the horizontal plane, as is shown on the process of Fig. 3.6.

The position and slope of the balance lines are determined by the designer in charge of the mould loft. These lines define the places where the connection of the frame parts is made. The distance between these lines is defined according to the size of the timber that is part of the frame.

As seen in Fig. 3.6, righthand side, we place a wooden stick over the balance line (in this case, line 3), marking all the intersection points between the stick and the frame lines on the stick.

Next, on the horizontal plane, Fig. 3.6, on the lefthand side and over the lines of each frame, we mark, using the stick, all points that will define the curves of the balance lines. These lines will be drawn on the horizontal plane to get the slope angles of the narrowing of the frames. This procedure is applied to all balance lines, deck line and border line.

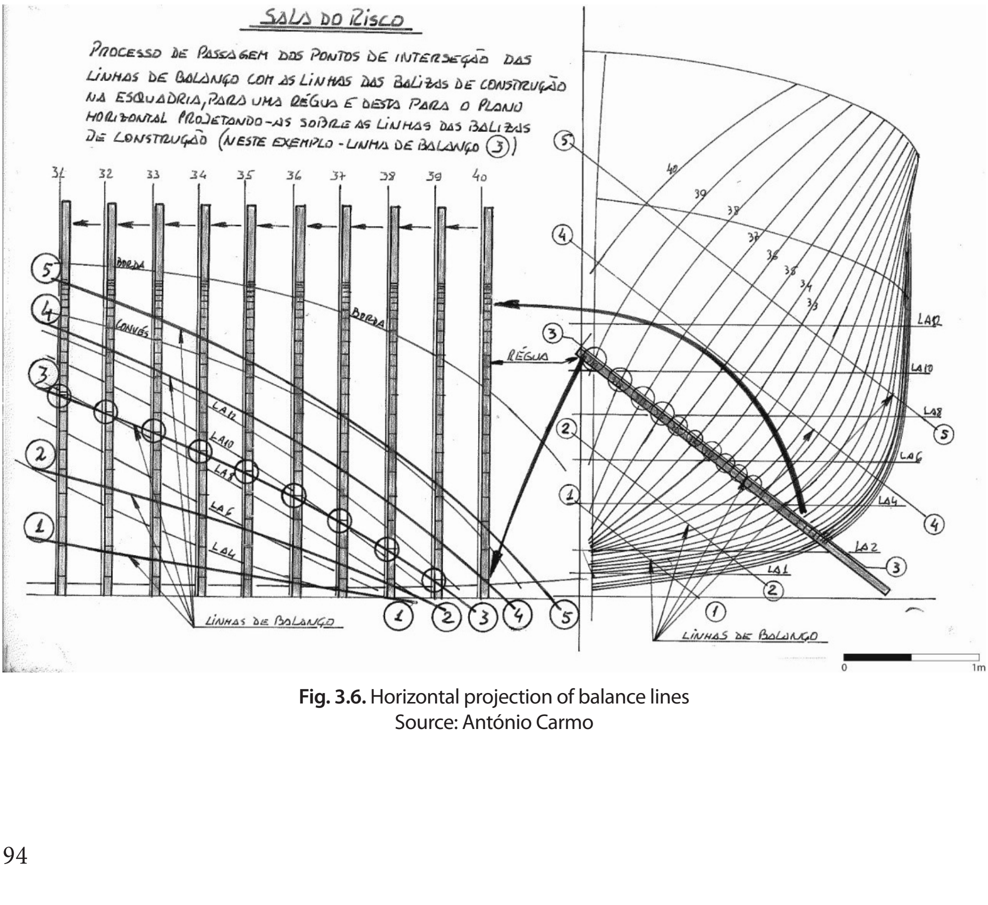

Fig. 3.6. Horizontal projection of balance lines
Source: António Carmo

2.7. The Slope Angles' Wooden Board

On this wooden board, we keep recorded the angles between the frame line with the tangent to the balance line curve at the intersection point with the frame line. We also record the width lines of all the connection parts.

In Fig. 3.7, lefthand side, we can see how, with the help of a sliding T bevel, the angles at the balance lines and all frame lines are measured. Then, these are transposed to the wooden board (Fig. 3.7, righthand side).

On the slope angles' wooden board, on one side, we mark all seven sets of the bow's slope angles (balance lines 1 to 5, deck line and border line). On the other side of the board, we mark the stern's slope angles.

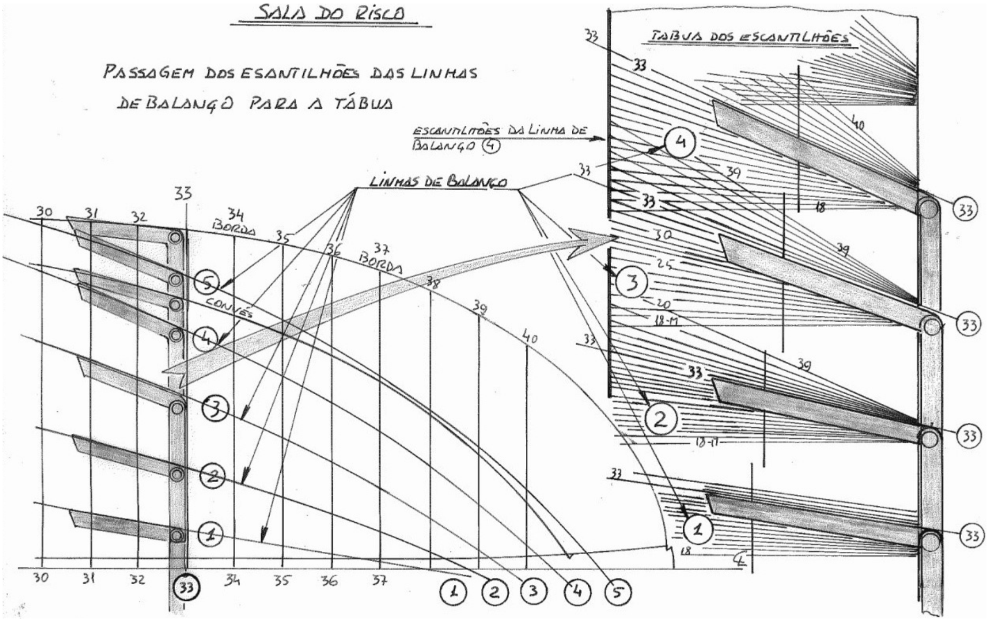

Fig. 3.7. Transferring from the balance lines slope angles to the slope angles' wooden board, between the 30th and the 40th frames
Source: António Carmo

2.8. Process to Determine the Transversal Width of the Connection Parts

This process is divided in two steps that complement each other:

1st — After all frame lines are drawn on the plane of the frames' transversal sections, we place a spline over the master frame's line, in this case number 18, depicting the same curvature. We transpose to the spline all intersection points of the master frame's line with the CL line (center line), with the balance lines (1, 2, 3, 4, 5), with the deck line and with the border line — Fig. 3.8.

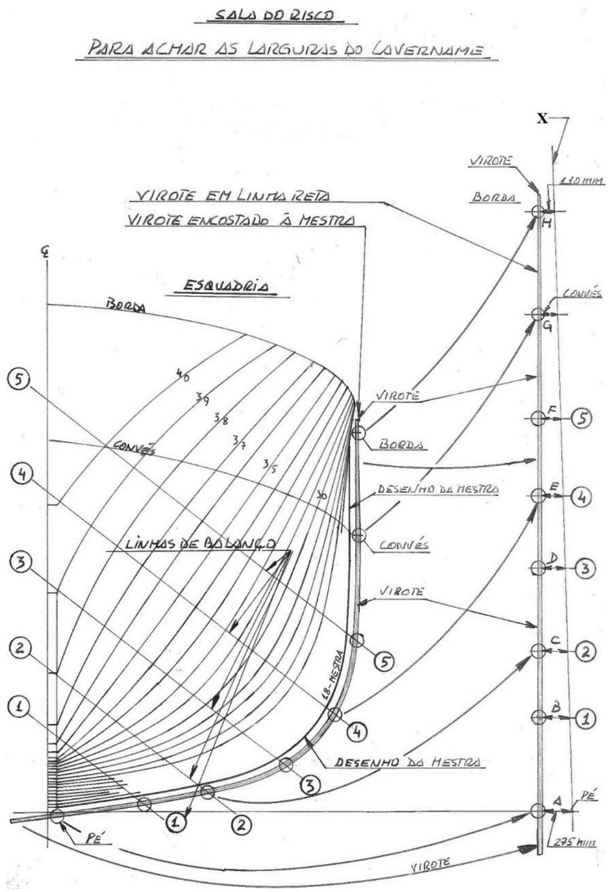

Fig. 3.8. Width extraction to the spline (1st step)
Source: António Carmo

2nd — The spline is put on the floor in a straight line (Fig. 3.9). At the *pé do virote* point (spline's foot point — the intersection point between the CL line with the master), we mark in a straight line the width of the frame's foot, stipulated on the project — in this case 275mm. Then, on the other side of the spline — that is, the intersection point between the master with the border line — we mark, equally in a straight line, the width of the top futtock on the border — which, in this case, is 110mm. We draw a straight line between these two points (foot and border). From the remaining points marked on the spline (balance lines 1, 2, 3, 4, 5, deck and border), to the line, we get the B, C, D, E, F, G and H distance values. Those distance values are marked on the wooden board by line segments, parallel to the right side of the board, over the set of corresponding balance lines (Fig. 3.9, righthand side).

The width of the frames we will shape is obtained with the compass at the angles board, over the angle line of the frame we are shaping, with the same angle value, at the corresponding balance line, opening the compass' legs from the board's border until the line segment marked over the angles. Fig 3.9, righthand side, a process we shall delve into further on.

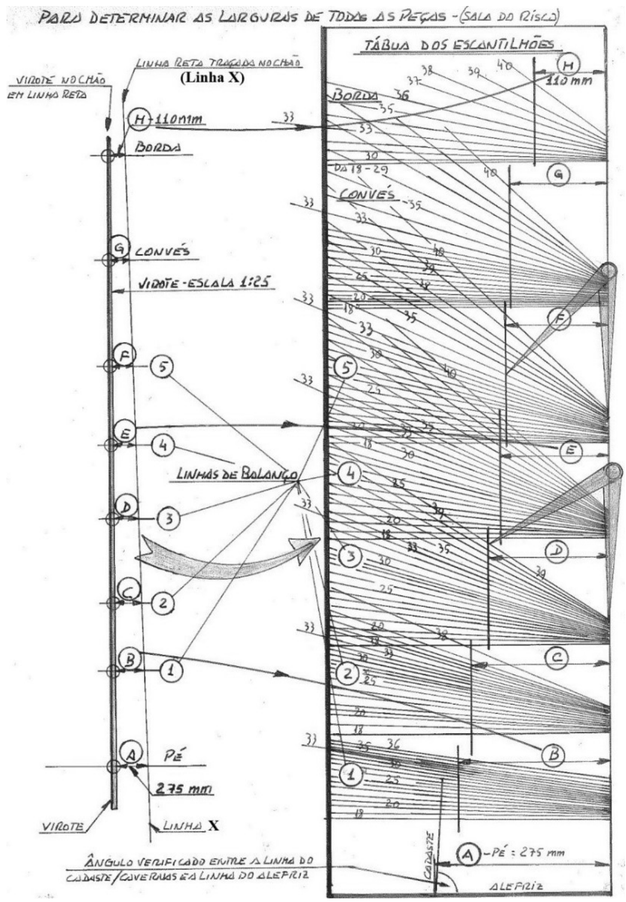

Fig. 3.9. Transposing the widths from the spline to the wooden board (2nd step)
Source: António Carmo

2.9. Execution of the Moulds for Wood Shaping

These are executed in pine wood sticks, with about 8mm thick and 80mm wide. The mould is constructed over the plan of the frames' transversal sections, being composed of three parts, divided by balance lines 2 and 4.

We transpose from the plane of the frames' transversal sections to the mould all the necessary marks to wood shape all frames. In figure 3.10 we can see the set of the bow's frame lines (righthand side) and the stern's frame lines, on the other side of the mould (lefthand side).

It should be noted that the size and quantity of moulds to be used and the position and quantity of the balance lines vary, according to the size of the vessel. This is determined at the mould loft.

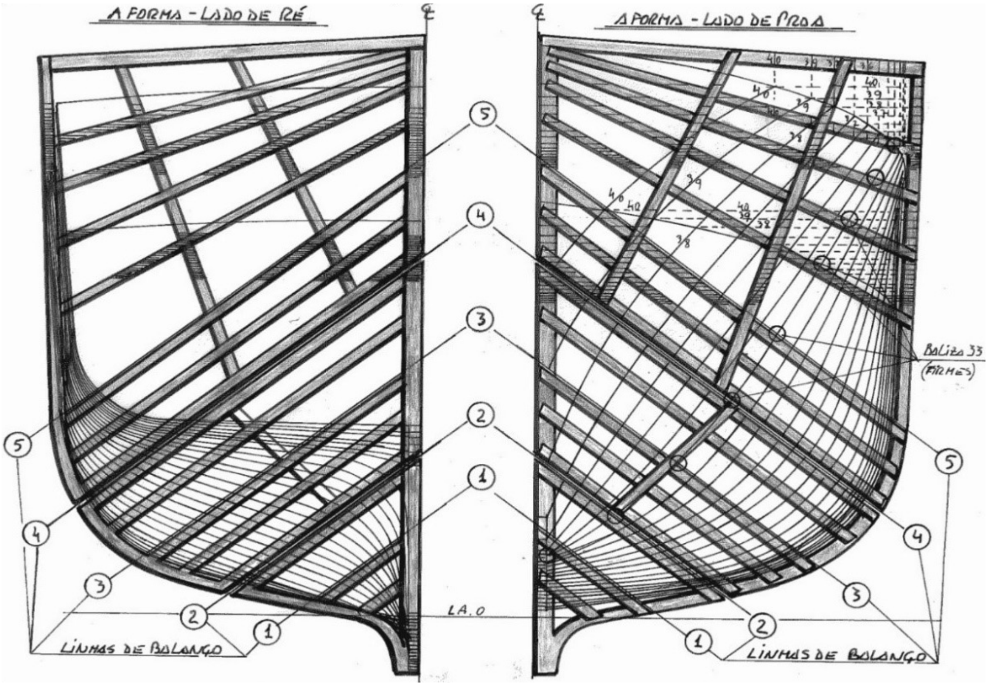

Fig. 3.10. Moulds for wood shaping the frames
Source: António Carmo

The mould is divided in three parts, Fig. 3.11 The bottom one, next to the keel, we call *bico* (lit. «beak»), the middle one, we call *chata* (lit. «flat»), and the top one, we call *grande* (lit. «big»).

The one named *bico* shapes the piece of the connection parts named floor timber (even numbers side), going from one side to the other, between both balance lines 2.

The one named *chata* shapes the piece of the connection parts named second (even numbers side), from balance line 2 to balance line 4.

The one named *grande* shapes the piece of the connection parts named fourth (even numbers side), from balance line 4 to the deck line.

By connecting the *bico* and *chata* parts, we shape the piece of the connection parts named first (odd numbers side), from the centre line (centre of the *bico*, that is) and balance line 3, at the *chata* mould.

By connecting the *chata* and the *grande* parts, we shape the piece of the connecting parts named third (odd numbers side), from balance line 3 at the *chata* mould to balance line 5, at the *grande* mould.

Finally, we shape only with the *grande* mould, the piece of the connection parts named fifth (odd numbers side), from balance line 5 to the border line.

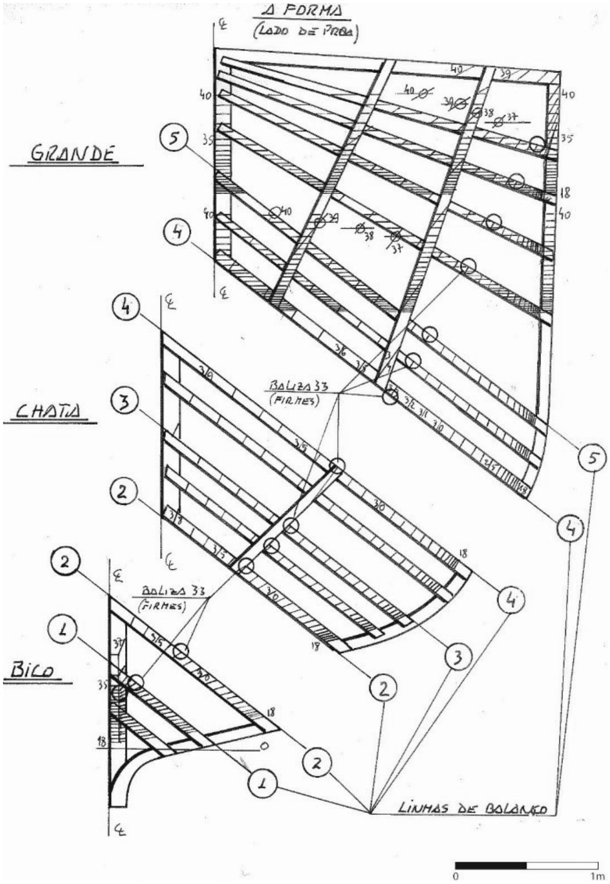

Fig. 3.11. Moulds for wood shaping the frames, apart
Source: António Carmo

3. PROCESS OF SHAPING THE FRAMES

3.1. How to Form a Frame — (Even Pieces and Odd Pieces)

In the previous sections we demonstrated the processes that take place within the mould loft, as well as how to get and make the framework moulds and the slope angles' wooden board. We wil now see how we design the frames using the models — a process called wood shaping.

As we previously said, the frames are doubled, having half of the connection parts for the bow and the other half for the stern. All these parts fit by counterlocking (tops of the connections of the bow's and stern's parts, mismatched and alternated). The position of these tops, where divisions are made, at the same lines where the mould's division was made, are coincidental and determined by the balance lines. We only have a single line available for each frame, called frame line, and it is this line that we use as basis for all the wood shaping process.

Wood shaping consists in drawing that line and 5 more directly on the wood, which in turn enables us to ascertain its real volumetry.

These are the initial steps of all the process. Keep in mind that none of the 6 lines in a parabolic arch that constitute a frame, and that we need to draw on the wood, are equal, making this a highly complex process.

In Fig. 3.12, which details the design of frame 33 in perspective, we can see the frame line (centre line through the external side of the frame), that splits the bow and stern parts, being virtually intersected by the balance lines, intersections which are marked with small circles (numbered 1 to 5) over the frame line. We can also see how the stern's parts are positioned, in this case called evens, and the bow ones, called odds (which we will talk about in the next chapter), as well as the way we determine the joining of the connection parts by the balance lines.

In Fig. 3.13, which pertains to the design of the transversal plane of the same frame, we can see on the left the central face and the splitting of even parts being intersected by balance lines 1 to 5. On the righthand side, we see the longitudinal design of the frame over the keel with the even parts and odd parts joined by the central face.

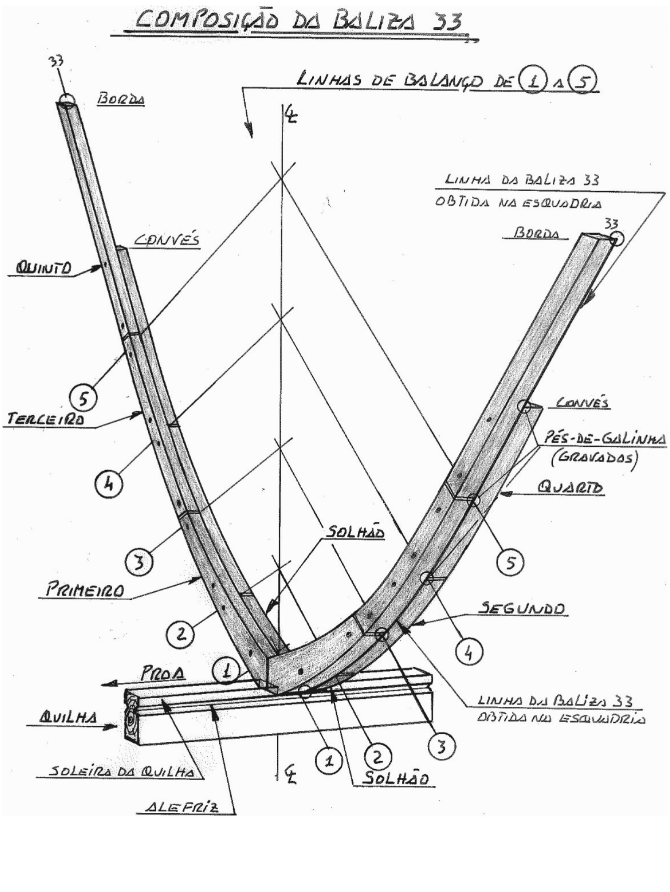

Fig. 3.12. Design of frame 33 in perspective
Source: António Carmo

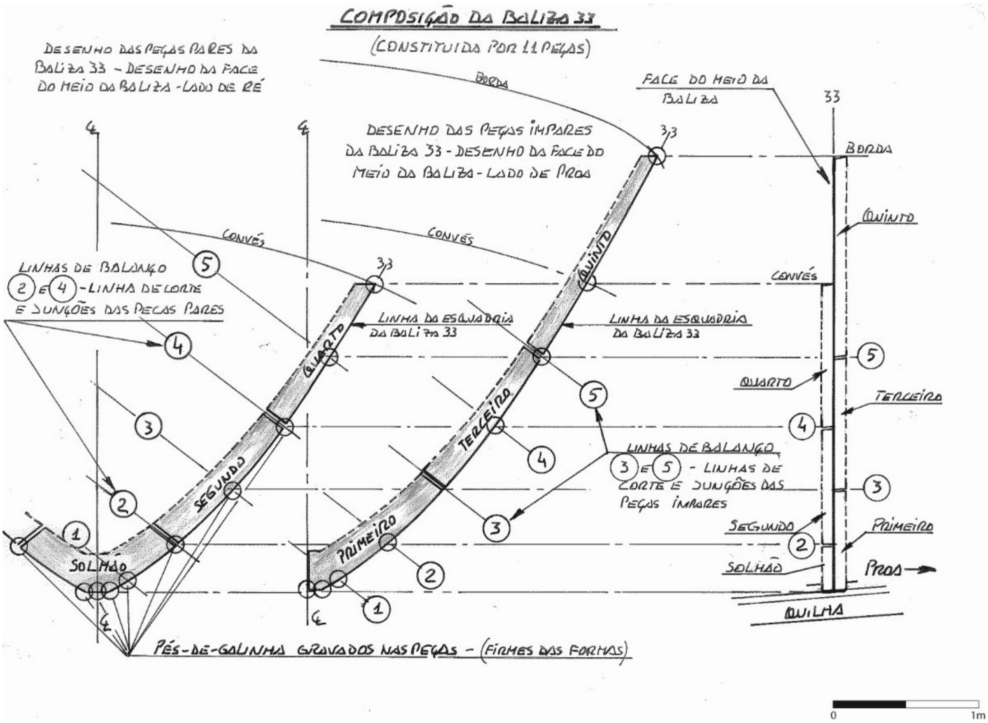

Fig. 3.13. Section in the middle of the frame, dividing the odd and even parts
Source: António Carmo

3.2. Rule of Inversion of Wood Shaping, Slope Angles Inversion and Inversion of the Position Between the Even and Odd Parts, From the Master Frame to the Bow and From the Master Frame to the Stern

The shaping of the frames' connection parts constitutes one of the most complex techniques of all wood shipbuilding. There are a few rules that guide the craftsmen and enable their work to proceed smoothly. Hence, there are rules that define different procedures when shaping the connection parts of the frames from the master to the bow and from the master to the stern. As we have mentioned previously, all frames are doubled, comprising sets of connection parts to the bow and sets of connection parts to the stern. So, it is stipulated that the parts to the set of the frame's connection parts that are facing the middle of the boat are named «even parts», while those that are facing the edges of bow and stern are referred to as «odd parts».

As we can see in Fig. 3.14, in the master frame we reverse the way of shaping.

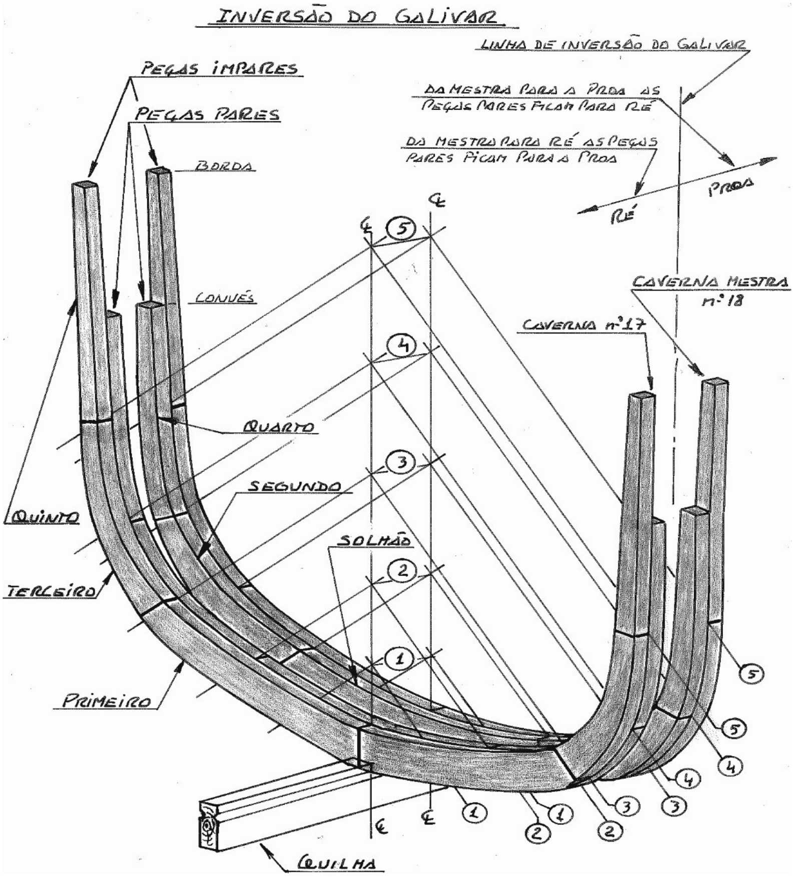

Fig. 3.14. Reversing the position of the even parts with the odd parts in the master frame
Source: António Carmo

As the layout of the hull is wider in the middle and becomes progressively narrower toward the edges, as we wood shape from the frame's middle line (frame line) to the bow and stern and as we always have the even parts facing the middle of the vessel, it's stipulated that to shape even parts, we always use slope angles called *cheios* (lit. «full» — obtuse angles), over 90 degrees. This has to do with the fact that the slope angle that starts from the frame line, of the even parts, faces the stern in the bow's frames, and faces the bow in the stern's frames. Instead, on the odd parts that remain on the opposite side of the even ones, facing the edges, the slope angle starting from the frame line faces the bow at the bow's frames, and faces the stern at the stern's frames, always less than 90 degrees, what we call *sulinhados* (acute angles). This gave rise to a saying, one which is useful to avoid mistakes during the aforementioned process: «the evens are to be used for the obtuse and the odds are always to be used for the acute» (see Fig. 3.15).

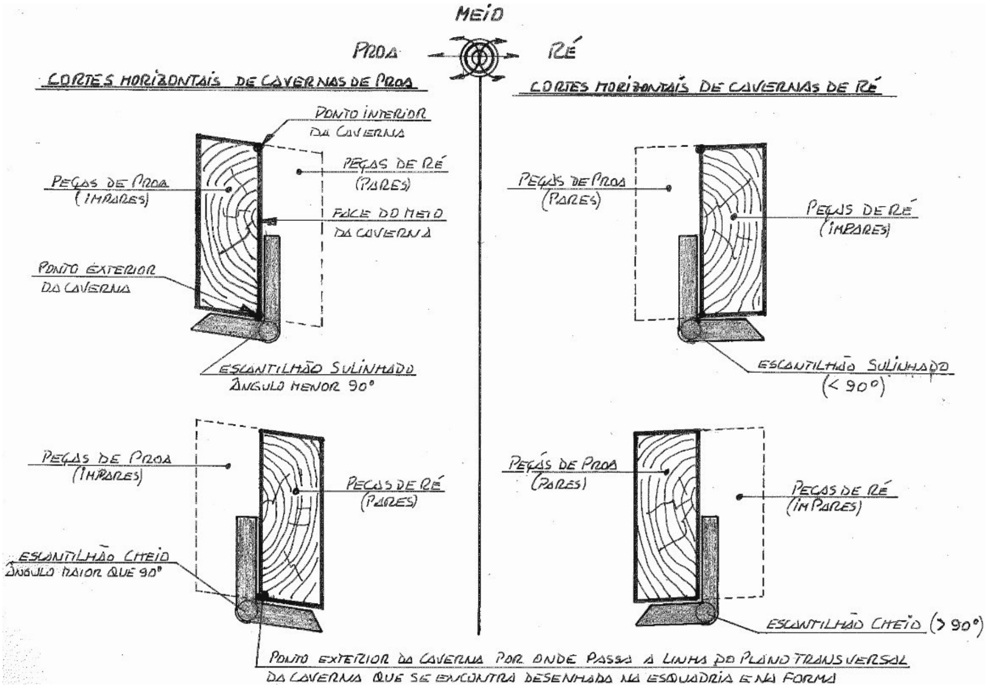

Fig. 3.15. Obtuse slope angles and acute slope angles
Source: António Carmo

3.3. Demonstrating the Wood Shaping of Frame 33

We will now present the process of wood shaping of only one frame, in this case 33, as the process is the same for all other frames, albeit with a different design.

3.3.1. Wood Shaping the Floor Timber of Frame 33

Using the appropriate moulds, we start shaping the floor timber. As we have seen, the floor timber is the only part of the frame that goes through the centre line, serving as a structural connection for both sides.

The first step is to draw in the wood the bow's face of the floor timber, which is also the frame's middle face. As the *bico* only had the design of one side, the other side will be «mirror copied». To mirror to the other side, it's common to have another *bico* that was «mirror drawn» in the mould loft. Both *bicos* are put against each other over the centre line and according to the balance lines, obtaining the total size of the floor timber. Both *bicos* are put on the wooden board, checking if its size is enough, always leaving some room, to the other side, as the part widens to the stern's side. Balance lines 1 and 2 are transferred from the mould to the wooden board and the *chicken feet* (or markings) that are relevant from the exterior line of the floor timber (intersection between frame 33's line with balance lines, centre line and keel width lines, marked on the several marking woods of the mould. Fig. 3.16, lefthand side). Intersecting the points and lines marked on the wooden board, with the aid of a spline, we draw the line facing the floor timber's exterior, facing the bottom of the hull.

We will now draw the line that defines the upper outline of the floor timber, facing the hull's interior. For that, we use the data we have on the slope angles' wooden board. As we see in Fig. 3.16, right side, the slope angles' wooden board shows the widths of the floor timber in balance lines 1 and 2. Using the compass, we take these measurements, which we name B' and C', and transpose them to floor timber wooden board (Fig. 3.16).

Hence, we attain the design of all the bow's face of the frame 33's floor timber (frame's middle face). We now need to draw the other face of the floor timber, its stern face (also frame's stern face).

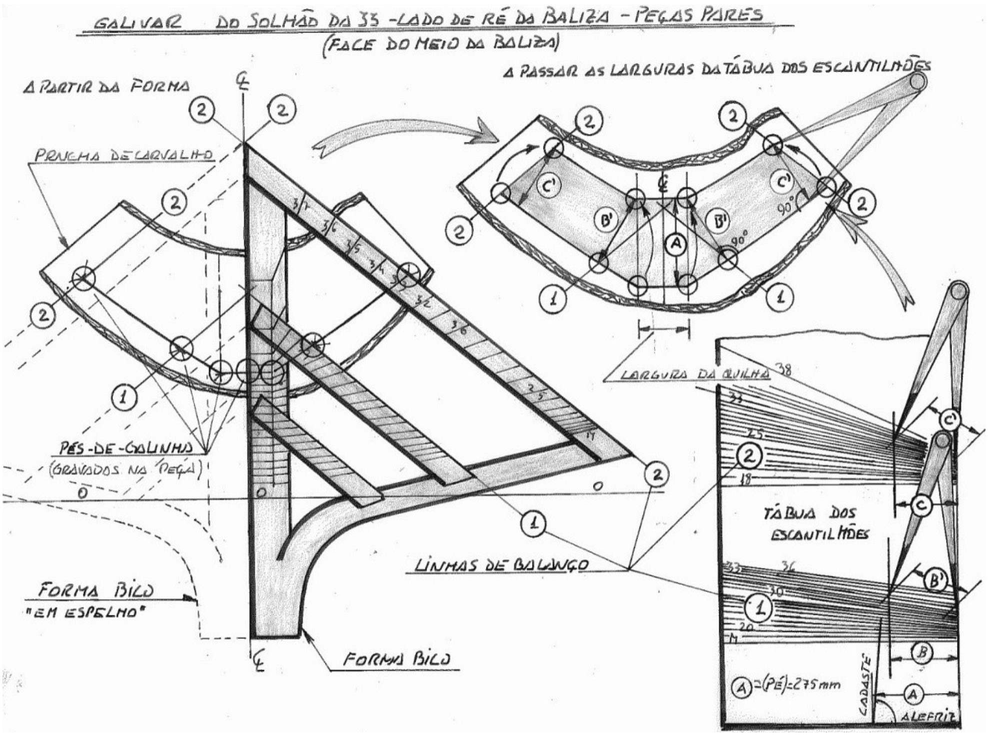

Fig. 3.16. Wood shaping the floor timber of frame 33
Source: António Carmo

3.3.2. *Counterdrawing* the floor timber of frame 33

As the frame 33 is positioned by bow of the master's frame, its floor timber is facing the stern, we will next have to design its stern's face. To the process of drawing the other side of the frame, we call *counterdrawing* (in Portuguese *contralinhar*).

We transfer the keel lines, the middle line and the balance lines from one face of the floor timber to the other, a process made with the help of a U-shaped handcrafted tool we call a *counterdrawing* grid, whose legs enter, with a bit of slackness, in both sides of the part, which allows us to make the concordance of the lines from one side to the other (Fig. 3.17).

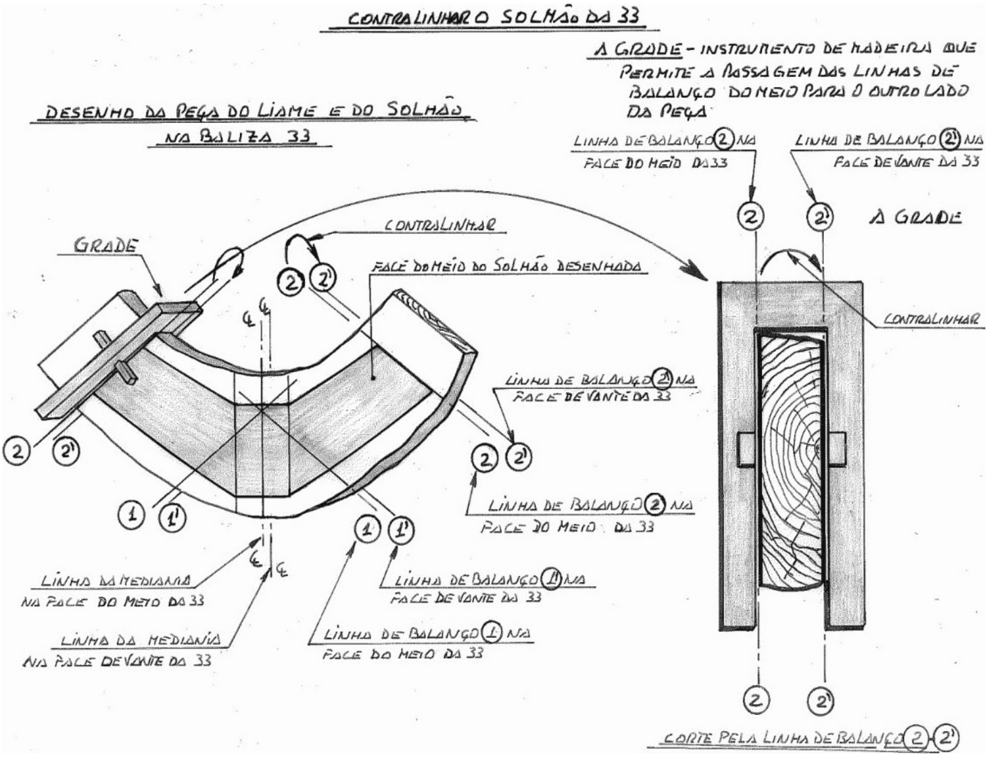

Fig. 3.17. *Counterdrawing* — Image of the *counterdrawing* grid
Source: António Carmo

Starting from the face drawn on the floor timber (bow's face), we will draw the other face, the stern's face of the floor timber (Fig. 3.18). With the sliding T bevel, at the slope angles' wooden board, we «take the angles» of frame 33 over balance lines 1, 2 and foot, bringing the bevel with those angles to the floor timber's board we want to *counterdraw*. We put the handle of the bevel over the corresponding balance line, turning the other side to the side of the face that is to be drawn. The interior part of the bevel's mobile stick is leaned against the wood that is in excess. With the bevel and the compass, we first transfer the intersection points between the frame line and the balance lines to the other side, points of the external outline, as shown in figure 3.18. Next, we measure, with the compass over the balance lines, the width on the line of the floor timber's bow side, transferring it over to the side of the stern. This way, we get the outline of the floor timber's stern face. The board will finally be cut around in the bandsaw, following the lines and slopes designed, making the floor timber set for completion.

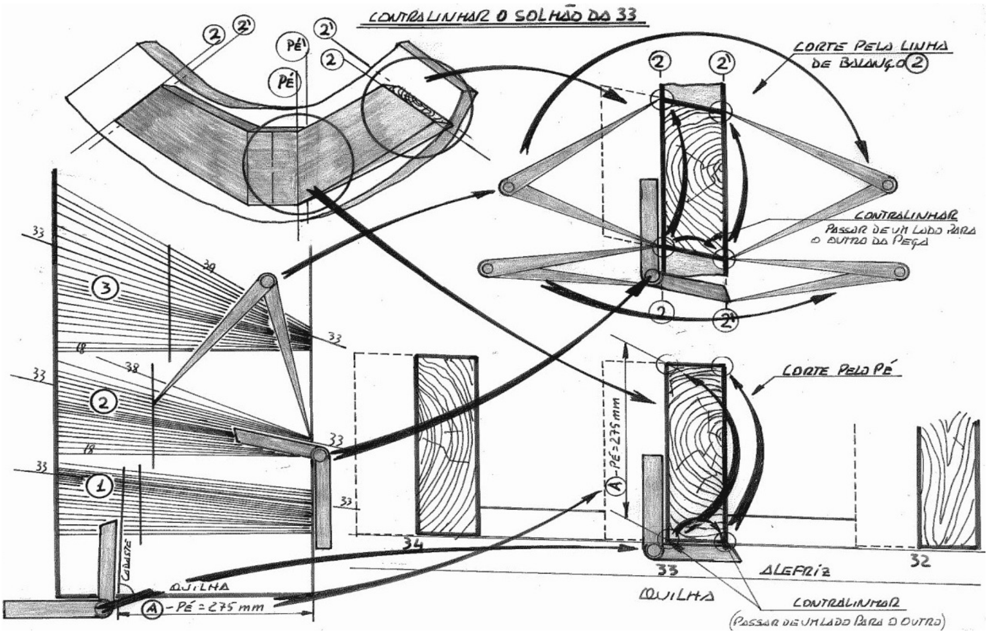

Fig. 3.18. *Counterdrawing* the floor timber of frame 33
Source: António Carmo

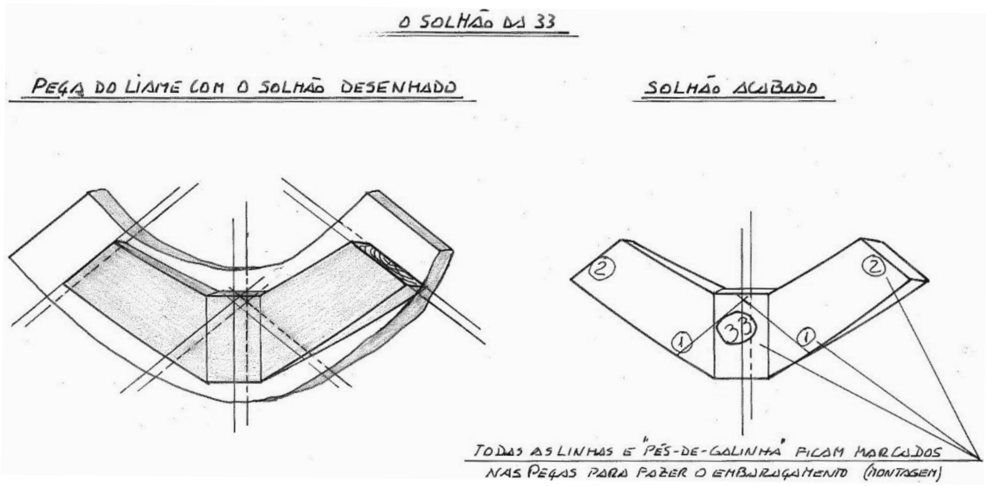

Fig. 3.19. The completed floor timber
Source: António Carmo

3.3.3. Wood Shaping and *Counterdrawing* the Remaining Even Parts of Frame 33

The sequence of the following images (Figs. 3.20, 3.21, 3.22, 3.23 and 3.24) show how to wood shape and *counterdraw* the remaining even parts, which form frame 33 (the second and the fourth). As the process is the same as used for the floor timber, we only illustrate it through images.

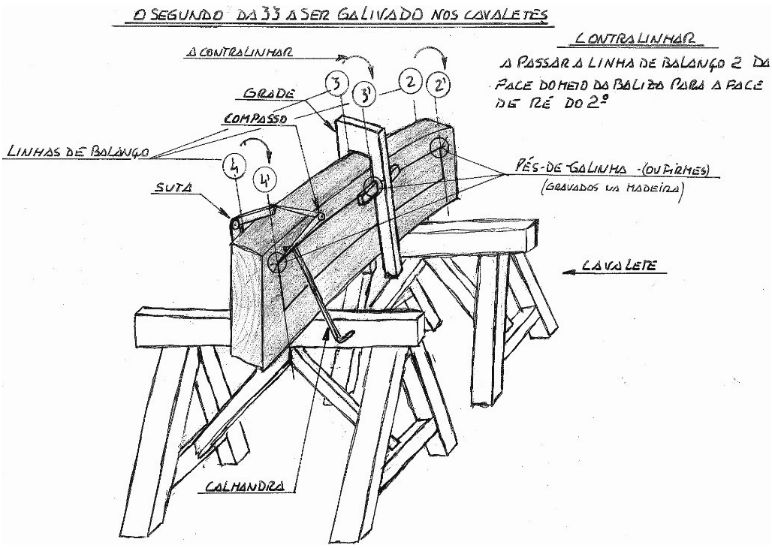

Fig. 3.20. Wood shaping the second of frame 33 at the easels
Source: António Carmo

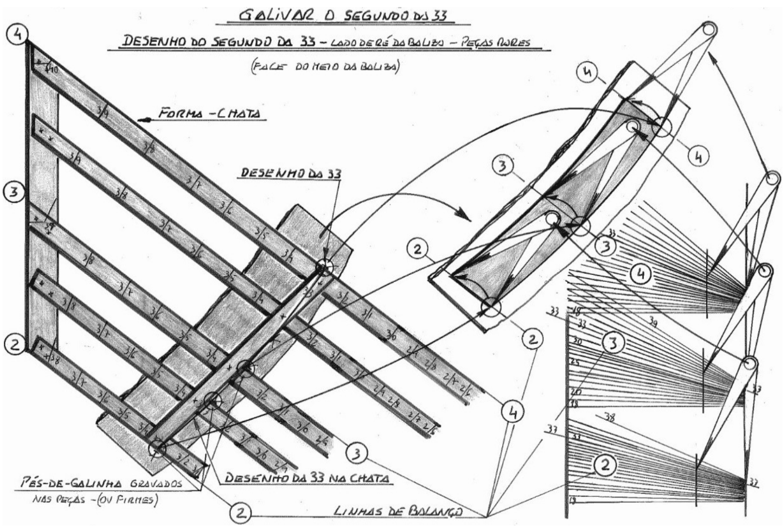

Fig. 3.21. Wood shaping the second of frame 33
Source: António Carmo

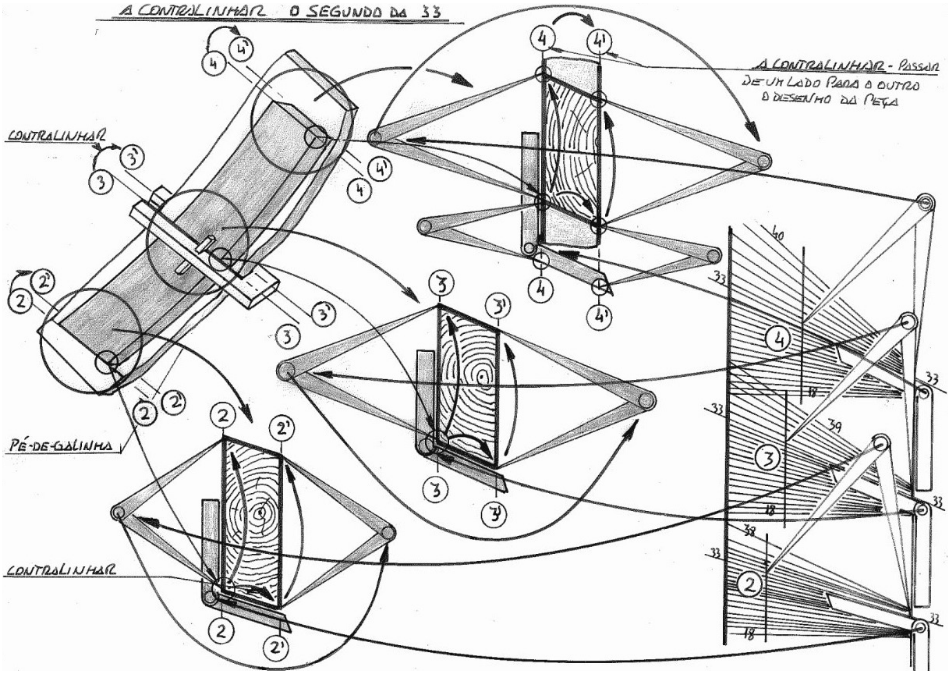

Fig. 3.22. *Counterdrawing* the second of frame 33
Source: António Carmo

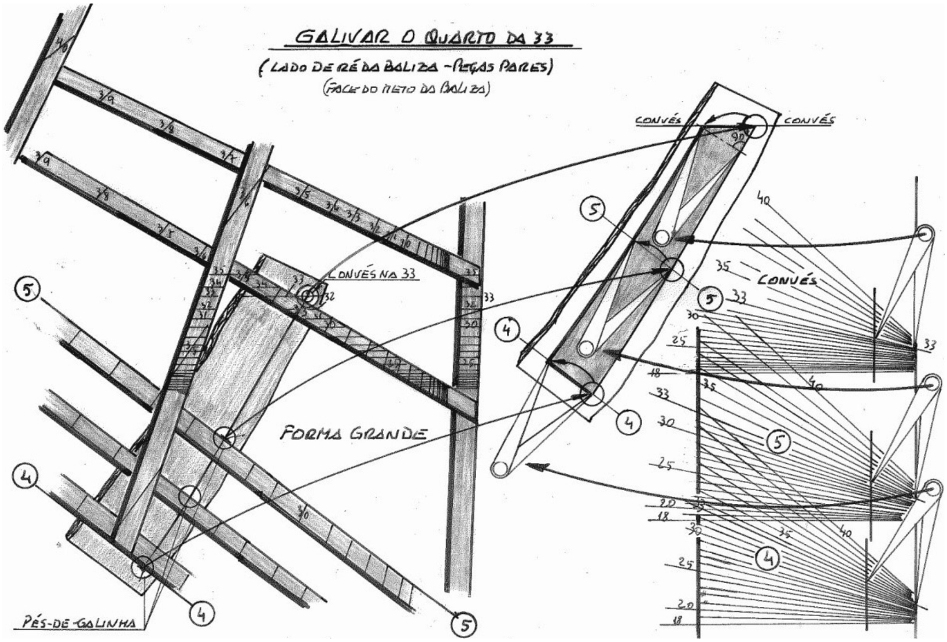

Fig. 3.23. Wood shaping the fourth of frame 33
Source: António Carmo

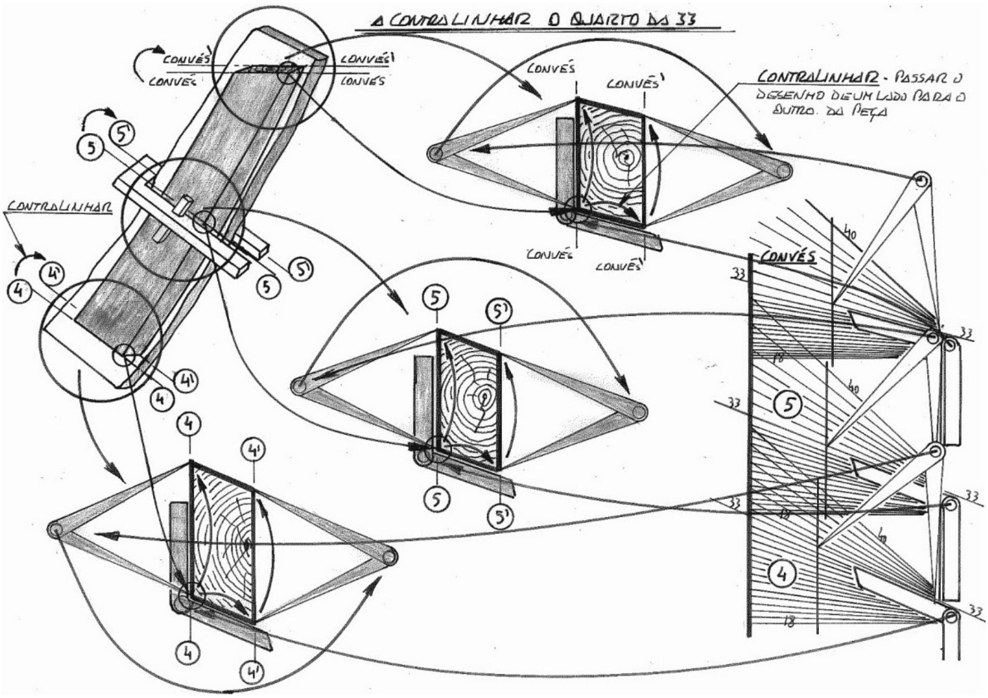

Fig 3.24. *Counterdrawing* the fourth of frame 33
Source: António Carmo

3.3.4. Wood Shaping and *Counterdrawing* the Odd Parts of Frame 33

For the odd parts (bow parts), in this case of frame 33, we use:

- For the first one, the *bico* mould and the *chata* mould — in between the centre line and balance line 3;
- For the third part, the *chata* mould and the *grande* mould, in between balance line 3 and balance line 5;
- For the fifth one, we only use the *grande* mould, in between balance line 5 and the border line (Fig. 3.25).

3.3.5. «Marrying» the Connection Parts

As the boat is symmetrical, we only wood shape the connection parts of one of the sides, using the completed part for mirror copying, a process known as «marrying» (from the Portuguese term, *casar*) and that consists in putting down the completed part on the wooden board used for drawing, serving as a mould. In order to avoid mistakes we wood shape the bow frames of the portboard side (in this case of frame 18 — master), until frame 40, and then we «marry» it to the starboard side. We shape the stern's frames from the starboard, from frame 17 until the panel and then we marry it to the portboard side.

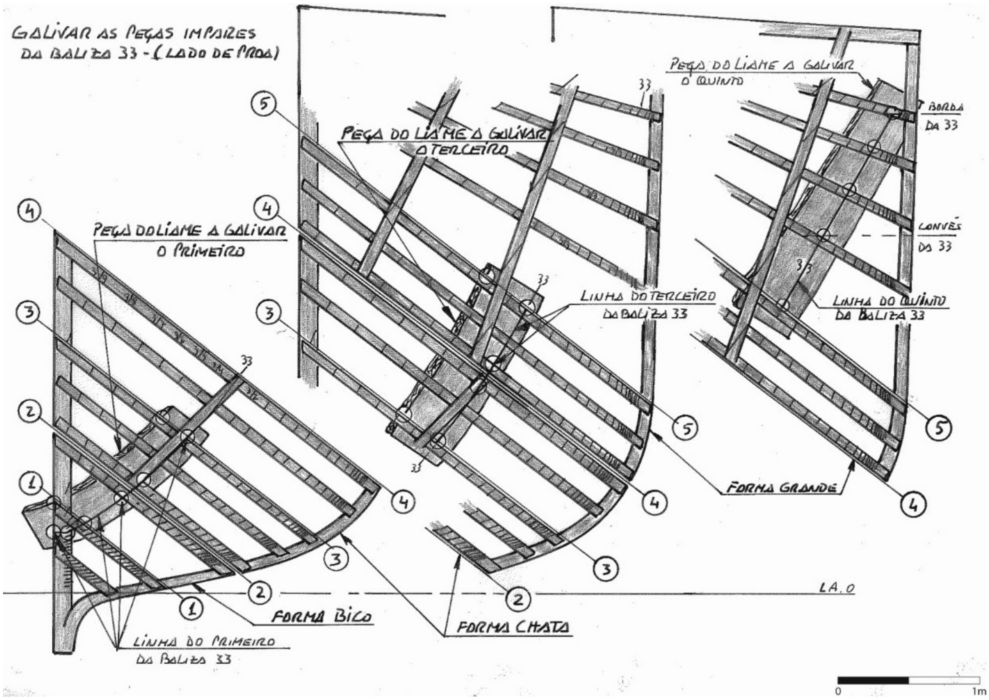

Fig. 3.25. Wood shaping the odd parts (the first, the third, and the fifth)
Source: António Carmo

4. THE FRAME FUTTOCKS CONNECTION

The *embaraçamento* (connecting the connection parts) is the assembly of the connecting parts that were previously shaped.

4.1. The Markings Needed for the Connection

We mark in all shaped parts, all the *chicken feet* (markings carved on the wood pieces, with the balance lines' positions), as well as the frame number, the part number, which also enables us to ascertain whether a given part is even or odd, and the side to which it belongs, so we can easily identify it during the assembly process (*embaraçamento*).

4.2. *Undercutting* the Connecting Parts

In the middle faces of the frame's parts, which are leaned against each other, a small concavity is carved with the help of a plane (tool), in the middle and along all the extension of the parts, what we call *undercut* (*socavar* in Portuguese), so that when all the connection screws are screwed, the union will be perfect.

4.3. The Screws for the Connection Parts

In this case, these are 12mm screws, in zinc-plated iron achieved by the old method of dipping in a hot boiler. The heads of the aforementioned screws are hexagon-shaped and their edges are screwed by female threads, using rings.

CONCLUSION

The work presented here illustrates the technique of designing, the mould loft, the making of the moulds, the wood shaping, *counterdrawing* and frame futtocks connection, only relating to the starting stage of the entirety of the complex process of shipbuilding, using the unique techniques of Vila do Conde's naval carpentry masters. Well supported by the vast amount of knowledge amassed throughout the ages, the technique shown in the present paper is unique, as there are no known records of any other shipyard in the world using this process. As there are type of recordings of it, as it is only passed on by members only to other members of this shipyard, usually from fathers to sons, it is preserved only in the memory of very few craftsmen. The work expounded on here intends to be an effective support effort of traditional techniques of wooden shipbuilding, and we hope it contributes to the preservation of a knowledge that is far too valuable for both our maritime culture and to this industry's future in Vila do Conde and in Portugal.

ILLUSTRATED SOURCES

ARCHIVES of the firm Samuel e Filhos Lda., over 500 technical designs of ships built between 1948 and 2006.

CARMO, António José (1981-2006) — *Archives of the firm Samuel e Filhos Lda., technical design of ships built between 1981 and 2006.*

_____ (2015) — *Set of 7 designs of details recording execution techniques, during the repairs made on vessels «Romilda Paula» and «Senhora dos Anjos»*. Part of the registration process at the National Inventory of Intangible Cultural Heritage of the «Techniques of Wooden Shipbuilding and Repair of Vila do Conde».

SANTOS, J. Rodrigues dos (1900-1937) — *Several technical designs of ships built between 1900 and 1937.*

EDITED SOURCES

ALBUQUERQUE, Luís de, *coord.* (1989) — *Portugal no Mundo*. Lisbon: Publicações Alfa, 6 vols.

BAPTISTA, João (2004) — *Estaleiros navais artesanais de madeira no Norte de Portugal, sobrevivência ou reconversão*. «Ardentía», n.º 1, p. 33-39.

BARATA, J. da Gama P. (1970) — *O traçado das naus e galeões portugueses de 1550-80 a 1640*. Lisbon: Junta de Investigações do Ultramar. Sep. de: Revista da Universidade de Coimbra.

_____ (1989) — *Estudos de arqueologia naval*. Lisbon: Imprensa Nacional – Casa da Moeda, 2 vols.

BARROS, Eugénio E. (1933) — *Traçado e Construção das Naus Portuguesas dos Séculos XVI e XVII*. Lisbon: Imprensa da Armada.

BARROS, Eugénio Estanislau; FREITAS, A. Ferreira (1904) — *Construção naval*. Lisbon: Bibliotheca e Educação Profissional.

CAMPOS, Maurício da Costa (1823) — *Vocabulario marujo: ou conhecimento de todos os cabos necessarios ao navio, do seu poliame, e de todos os termos marujaes, e de alguns da construcção naval, e artilheria*. Rio de Janeiro: Officina de Silva Porto e Companhia.

CARMO, António José (2015) — *Glossário de construção naval em madeira, termos usados nos finais do século XX*. Part of the registration process at the National Inventory of Intangible Cultural Heritage of the «Techniques of Wooden Shipbuilding and Repair of Vila do Conde».

CASTANHEIRA, Edmundo (1991) — *Manual de construção do navio de madeira*. Lisbon: Dinalivro.

_____ (1998) — *Construção de pequenas embarcações*. Lisbon: Dinalivro.

CASTRO, Filipe Vieira (2003) — *A Nau de Portugal. Os navios da conquista do Império do Oriente*. Lisbon: Prefácio.

CORAZZI, David (1864) — *A arte naval*. Lisbon: author's edition.

COSTA, Leonor Freire (1997) — *Naus e galeões na ribeira de Lisboa: a construção naval no século XVI para a rota do Cabo*. Cascais: Patrimonia, col. Patrimonia Historica.

COUTINHAS, J. Manuel (1986) — *A Navegação Medieval na Foz do Ave*. «Suplemento do Jornal de Vila do Conde», n.º 342, p. 1-4, n.º 343, p. 1-2.

DOMINGUES, Francisco Contente (2004) — *Os navios do Mar Oceano, teoria e empírica na arquitectura naval portuguesa dos séculos XVI e XVII*. Lisbon: Centro de História da Universidade de Lisboa.

_____ (2008) — *Navios Portugueses dos Séculos XV e XVI*. Vila do Conde: Cadernos do Museu da Câmara Municipal de Vila do Conde.

[FARIA, Jorge de] (1989) — *Marinheiros e mareantes de Vila do Conde*. «Boletim cultural da Câmara Municipal de Vila do Conde», nova série, n.º 3, p. 37-40.

FERNANDEZ, Manuel (1989) — *Livro de traças de carpintaria, 1616*. Fac-símile. Lisbon: Academia de Marinha.

FONSECA, Quirino (1934) — *A Caravela Portuguesa e a prioridade técnica das navegações henriquinas*. Coimbra: Imprensa da Universidade de Coimbra.

FRÉMINVILLE, A. de (1864) — *Traité pratique de construction navale*. Paris: Arthus Bertrand-Libraire Maritime et Scientifique.

FRUTUOSO, Eduardo J. M.; GUINOTE, Paulo J. A.; LOPES, António M. B. [s.d.] — *A caravela e as condições de navegação na época dos descobrimentos*. [S.l.]: Grupo de trabalho do Ministério da Educação para as comemorações dos Descobrimentos Portugueses.

GUIMARÃES, Bertino Daciano; FREITAS, Eugénio A. Cunha e; NEVES, Serafim G. (1948) — *Azurara, concelho de Vila do Conde, subsídios para a sua monografia*. Porto: Junta de Província do Douro-Litoral.

LAVANHA, J. Baptista (1996) — *Livro primeiro de architectura naval, 1600*. Lisbon: Academia de Marinha.

LEITÃO, Humberto; LOPES, J. V. (1990) — *Dicionário da linguagem de marinha antiga e actual*. Lisbon: Edições Culturais da Marinha.

MENDES, Vítor (2013) — *Estaleiros navais de Sarilhos Pequenos*. Moita: Câmara Municipal da Moita.

MIRANDA, Marta (1998) — *Vila do Conde*. Lisbon: Editorial Presença.

NEVES, J. Pacheco (1987) — *Vila do Conde*. Vila do Conde: Secção Cultural da Câmara Municipal de Vila do Conde.

OLIVEIRA, Fernando (1995) — *Livro da fábrica das naus, c. 1580*. Fac-símile. Macau: Academia de Marinha; Museu Marítimo de Macau.

PEREIRA, A. Sousa [s.d.] — *Algumas considerações sobre o porto de Vila do Conde*. In *Estudos Vilacondenses*. Vila do Conde: Edições SER, vol. II.

_____ [s.d.] — *Mais algumas considerações sobre o porto de Vila do Conde*. In *Estudos Vilacondenses*. Vila do Conde: Edições SER, vol. III.

PEREIRA, J. A. Rodrigues (1968) — *História da Marinha de Guerra Portuguesa*. «Anais do Clube Militar Naval», vol. XCVIII, tomo 7-9, p. 437-477.

PILOTO, Adelina; SANTOS, A. Monteiro (2007) — *Naufrágios: História Trágico-marítima de Vila do Conde, 1588-2006*. Vila do Conde: Câmara Municipal de Vila do Conde.

POLÓNIA, Amélia (2007) — *A expansão ultramarina numa perspetiva local. O porto de Vila do Conde*. Lisbon: Imprensa Nacional – Casa da Moeda, 2 vols.

REIS, A. Carmo (2008) — *Vila do Conde na Época dos Descobrimentos*. Vila do Conde: Museu de Vila do Conde; Câmara Municipal de Vila do Conde.

REIS, JOÃO dos (1951) — *Coisas do passado, gente humilde*. Vila do Conde: Gráfica de Santa Clara. (Interesting appointments about the life of the shipyards and fishing in Vila do Conde during the eighteenth and nineteenth centuries)

SAMPAIO, Alberto (1979) — *As póvoas marítimas*. [S.l.]: Editorial Vega.

SEGRELLES, Vicente (1985) — *História ilustrada dos barcos*. Porto: Livraria Civilização.

II

BUSINESS AND KNOWLEDGE

PUBLIC OR PRIVATE? SUBCONTRACTING FRENCH NAVAL VESSELS IN THE SEVENTEENTH AND EIGHTEENTH CENTURIES

DAVID PLOUVIEZ

INTRODUCTION

In 1690, the artist Nicolas Berquin produced a series of drawings depicting the shipyards of the Arsenal of Rochefort, where vessels and galleys were under construction (see Appendix 1). At a time when France was fighting the War of the League of Augsburg (1688-1697), we can see an arsenal given over entirely to the war effort, with each scene showing the overall organization of the shipyards and the various trades (carpenters, sawyers, drillers, and other kinds of shipwrights, etc.). But while these drawings are important documents for the historian looking to reconstruct the working environment of a European arsenal in the Early Modern era, they tell us nothing about the economic arrangements chosen by France to build its fleet. Are the craftsmen portrayed by Berquin working for the arsenal, a contractor, or both? Is the vessel's construction being overseen by the commander of the port or by an entrepreneur who has signed a contract with the State?

In France, when it came to building and maintaining a permanent fleet of warships under the *Ancien Régime*, it was essential to use contractors to build vessels for the war effort, which led to novel ways of organizing the sector and exchanging know-how. Surprisingly, however, there have been very few studies of naval subcontracting, despite the wealth of synthetic works available about the building of warships during this period[1].

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[1] ACERRA, 1993.

By drawing on a corpus of documents on subcontracting for the construction and maintenance of warships, ranging from the 1620s to the eve of the French Revolution, this study aims to flesh out this process. It is therefore necessary to contextualize these subcontracting practices both at European level and in the framework of French naval policy, while considering the technical objects created and those who created them.

1. NAVAL SUBCONTRACTING IN EUROPE: A UNIVERSAL PRACTICE?

The creation of national navies that characterizes Europe in the Early Modern era has provided material for a rich historiography, although to varying extents for the different navies concerned and the subjects addressed[2]. While the arms race and the increase in tonnage of naval fleets starting in the middle of the seventeenth century and the changes in shipping design and port infrastructure have been the focus of renewed attention since the 1960s and 1970s[3], the economic and financial aspects that underlie these naval policies have not yet given rise to a comprehensive and comparative approach, particularly for France[4].

More has undoubtedly been achieved concerning the English and, to a lesser extent, Dutch and Spanish fleets, which had been studied very early on and again with renewed interest since the debates in the 1990s about the notions of the «fiscal-military state»[5] — or the «fiscal-naval state»[6] — or even the «contractor state». This latter trend in research has helped shed light on the mechanisms enabling states to maintain larger and better-equipped armies and navies, through an improved understanding of the way administrations functioned, the construction and dissemination of military knowledge, the actual potential of taxation, and the burden of war on the economies of these States. In particular, the complex relationships between the private and public sectors, by contracting out military requirements, were seen very early on as key for understanding a State's capacity for military mobilization, especially of its naval forces.

These studies show the importance of subcontracting in the construction of fleets, though in different ways and to different extents in the various naval powers. Without oversimplifying a complex phenomenon[7], from the sixteenth century onward Spain delegated a considerable part of the construction of its vessels to entrepreneurs in the Peninsula, in particular in Basque and Cantabrian ports such as Gijón, Avilés, Ribadeo,

[2] GLETE, 1993.
[3] LLINARES & HRODEJ, 2010.
[4] PLOUVIEZ, 2016.
[5] TORRES-SÁNCHEZ, 2007.
[6] BOWEN & GONZÁLEZ ENCISO, 2006; CONWAY & TORRES-SÁNCHEZ, 2011.
[7] The subcontracting of shipbuilding did not always lead to the construction of «finished» vessels, but more frequently of hulls, the most important part of the project both technically and financially. In this first part, I make no distinction between the subcontracting of hulls and of complete ships.

Gamero, Pasajes, and San Sebastián[8], and also throughout its Empire. This tendency was concomitant with the establishment of legislative provisions facilitating the work of the shipyards[9] and a slow standardization of ships' characteristics. Yet it did not prevent the development of State arsenals (Cartagena, La Carraca, Ferrol, and Havana), even though these infrastructures were never able to assume the entire work of construction and repair on their own, particularly during times of conflict. Spain thus developed an original model in Europe that resulted in a substantial proportion of its military needs being delegated to private businesses.

England and the United Provinces moved in stages toward the massive subcontracting of their fleets. In the seventeenth century, the practice was marginal in Britain, which generally speaking managed to build its own ships, except for brief periods during the reign of William III when recourse to private shipyards was required, while the five Dutch Admiralties built a small number of ships and leased the rest of their fleet from merchants. The rapid succession of conflicts in the eighteenth century forced the Royal Navy to entrust part of the construction of its frigates and lighter vessels to private shipyards, mostly located on the River Thames, before gradually subcontracting for larger vessels (see Table 4.1). The British arsenals remained important for all the phases of arming, gathering supplies and, especially, the maintenance and repair of ships-highly technical tasks that the Admiralty did not wish to delegate to private contractors.

Table 4.1. Subcontracting for the British Fleet, 1688-1815

	Number of Battleships	**Tonnage**
Private Shipyards	244	322,010
Royal Arsenals	392	521,135
Total	**636**	**843,145**

Source: LAVERY, 1983: vol. 1, 163-190, taken up in KNIGHT, 1988: 59

This movement toward subcontracting on a massive scale was never subsequently questioned and represented nearly 72% of the tonnage launched during the French Revolutionary Wars (1793-1815)[10]. This occurred later in the Dutch Republic, which fully adopted the process during the American Revolution when it was unable to build enough vessels in the Admiralty shipyards alone, especially as they had produced little in the first half of the eighteenth century. By having recourse to private shipyards, the

[8] PLOUVIEZ, 2013.
[9] This was particularly the case for forestry: GOODMAN, 1997.
[10] During this period, private British shipyards launched 60 ships of the line and 627 other secondary vessels, for a total of 354,772 tonnes, or 72% of all military shipbuilding: MORRISS, 1983: 28.

country was able to produce an unprecedented number of vessels, launching 36 ships of the line and 54 frigates between 1778 and 1789.

All European states subcontracted out the construction of at least part of their fleets, proportionally to the burden of the war effort, and also because of many structural parameters such as the availability and quality of public port infrastructures or the ability to raise the necessary funds. Furthermore, the best sources for studying these practices are to be found among the navies of the minor powers (Sweden, Denmark, Russia, etc.) that chose to build outside the state system[11], often in higher proportions than the major naval powers when they neither wanted nor were able to maintain substantial arsenals. Thus, the way the Danish fleet was built up before and during the reign of Christian IV is very instructive, as many possibilities were combined to increase its numbers. Complete construction of vessels in the arsenals of the kingdom, partial subcontracting under the direction of public shipbuilders and with equipment supplied by the arsenals, or complete subcontracting after signing a contract with a private contractor were all used with infinite variations, making Denmark a precursor — alongside Sweden[12] — of methods adopted by all the other European navies from the second half of the seventeenth century. At the beginning of the French Revolution, the Secretary of State of the French Navy, César Henri de la Luzerne, when reporting on his actions by comparing them with other European fleets, rightly emphasized that naval subcontracting had by then become a «universal practice»[13].

The situation in France on delegating naval construction is more complex to characterize. It is likewise difficult to understand the Navy's complex financial arrangements and its relationship with private enterprise from the seventeenth century through to the Empire considering that the archives — contracts, specifications, storebooks, etc. — were partially destroyed during major reorganizations in the nineteenth century. The only remaining possibility for learning about this essential area of military activity is to use the correspondence between the intendants, the commissioners, and the central authority or, much more onerous but leading to much richer results, to compile the agreements signed between the State and private operators for the supply and construction of ships. From the end of the eighteenth century, more documentary material concerning subcontracting becomes available with the correspondence and technical archives left by certain engineer-builders and some companies' archives, which grant insight into this process from the point of view of private actors.

In addition, the terminology used by the Navy to describe subcontracting in the Early Modern era is most unhelpful for the researcher seeking to understand this

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[11] BELLAMY, 1997: 377; BELLAMY, 2006.

[12] We should not overlook the contribution of the navies of Venice and the Ottoman Empire, which also inspired the fleets developed in the seventeenth century. For Sweden: GLETE, 2010.

[13] This citation originally in French and all following ones have been translated by the translator. *Mémoire de M. de la Luzerne sur les administrations dont il a été chargé*, 1790 (AN — *Colonies*, F^3 158).

phenomenon. In the various legal texts providing an organizational framework for the naval authorities, subcontracting is frequently referred to via expressions such as «award at a discount», «fixed-price contract», or «private contract», as opposed to work undertaken «par économie» or «à la journée du roi», which meant work done by the journeymen of the arsenals under the supervision of engineers or the Intendant. Although the practice already existed, the Navy Ordonnance of 1689 was the first legislative instrument to indicate that shipbuilding could be undertaken «at a fixed price and not by [number of] days worked»[14], thus recognizing the custom but without giving it a very precise framework. Moreover, it was never properly defined because apart from this one reference, no other official text provides any framework for the subcontracting that can be glimpsed in the various extant contracts, the correspondence describing the day-to-day work, or in the rare descriptions offered by observers, particularly at the end of the eighteenth century[15].

2. SUBCONTRACTING AND SHIPBUILDING POLICY IN FRANCE: SEVENTEENTH-EIGHTEENTH CENTURIES

As for the construction of the fleet, we can identify an initial period that extends from Richelieu's desire to equip France with a permanent Navy until the beginning of the personal rule of Louis XIV. In the absence of a complete range of infrastructures and trained carpenters, the State had no other choice than to entrust the building of its Navy to private companies, both French and foreign. This was subcontracting as apprenticeship, with the dual purpose of providing ships as quickly as possible and of encouraging a process for training of a pool of men who would learn the shipbuilding trades and then be available to work in the French state arsenals. From then on, there were two levels of shipbuilding delegation, as a proportion of the smaller vessels and the routine maintenance were entrusted to tried-and-tested French private shipyards, mostly in Charente, Brittany, and Normandy, while the fighting ships were contracted out to Dutch shipyards and built in the United Provinces or in France. The fleet was built intermittently, but the distribution of tasks can generally be seen operating from 1626, the date of the first large-scale shipbuilding program led by Isaac de Razilly (see Table 4.2), a friend of Richelieu, until the arsenals were capable of fulfilling their missions in the 1670s and 1680s.

[14] *Ordonnance de Louis XIV pour les armées navales et arcenaux de marine, 1689*: titre II, art. III.

[15] The different attempts to reorganise the Navy during the Revolution are useful for understanding subcontracting: *Mémoire de M. de la Luzerne sur les administrations dont il a été chargé*, 1790 (AN — *Colonies*, F3 158; THÉVENARD, 1790: VIII; MALOUET, 1790).

Table 4.2. French shipbuilding program of 1626

Tonnage/Type of Vessel	Number
500	18
300	6
200	6
Tenders	10
Galleons	5
Total	**45**

Source: CASTAGNOS, 1989: 101-103

In 1626, six complete coastal protection vessels were ordered from Jacques Soullau of Dieppe[16], while other contracts were signed for specific tasks to be carried out on the ships already under construction, such as making the rigging, the interior arrangements, or a refit for example, as with the *Salamandre* and of the *Lionne* in 1632[17]. All these constructions were regularly inspected by delegates appointed by Richelieu (Beaulieu, Nicolas Leroy du Mé, and Razilly), who would either approve or not the way the work was progressing. At the same time, carpenters and «maîtres de hache» (men so skilled with their axes that they had no need of saws) were constantly honing their crafts as they circulated between shipyards. The contractual documents from this period offer interesting sources for the historian of naval architecture, showing the stages through which the ships proceeded via the accompanying specifications, which often mention the different dimensions (length of the keel, width of the beam, depth, etc.), the characteristics of the guns, as well as details on the internal fittings. However, these documents have little to tell us concerning the general economics of shipyard organization, how the work was done in practical terms, or the actors involved. There is more information in documents concerning larger vessels[18] of more than 400 tons, for which foreign carpenters were required. Here, certain clauses in the contract require the presence of French carpenters to work side-by-side with their Dutch counterparts. The subcontracting that occurred in the 1630s and 1640s had been a decisive step in the evolution of naval military architecture and the overall management of shipyards. The Dutch carpenters improved the French vessels by giving them lower lines, by decreasing the size of the after castle and increasing the artillery, while also encouraging the writing down of all these innovations in technical

[16] AN — *Minutier central des notaires parisiens* (hereafter MC), Marché de construction de six vaisseaux passé par Richelieu au nom du roi avec Jacques Soullau, marchand de Dieppe, 10 décembre 1626, XCVI-14.
[17] AD 76 — *Travaux d'aménagement de la Salamandre et de la Lionne*, 15 mars 1632, 2^{E} 70-190; I would like to thank Michel Daeffler for sending me these documents.
[18] AN-MC — *Marché pour fabriquer trois vaisseaux en hollande*, 12 novembre 1635, LXXXVI-309 fls. 1-6 r; BNF — *Marché fait avec les charpentiers hollandois*, 12 juin 1639, Ms Fr. 6408 fl. 503.

documents[19]. At the beginning of the personal rule of Louis XIV, subcontracting was still necessary to constitute a fleet, but the contracts were henceforth signed with French shipbuilders who had acquired their skills during the previous decades. In 1666, Laurent Hubac, the only man «qui puisse raisonner [who has the required knowledge]»[20], obtained a contract to build ten vessels at the arsenal of Brest. He was in fact unable to complete them, but this shows the new skills of such men[21].

The Navy acquired an administrative structure in the 1660s that enabled the arsenals to become progressively more independent in executing naval policy, especially after the 1671 regulation that every arsenal should have its own shipbuilding committee responsible for supervising the «measurements and proportions of the vessels to be built» and «examining, and possibly altering, the costs estimated by the master shipwrights»[22]. In peace time, far fewer shipbuilding contracts were awarded, and orders even dried up completely in some arsenals, leaving the Navy to pursue its shipbuilding programs alone. From then on, the recourse to subcontracting was characteristic of periods of conflict, dictated by logistic and economic imperatives as it was necessary to lighten the load on the arsenals whose order books were full while also building at lower cost — a practice common to all the navies of Europe in the same circumstances.

This emergency subcontracting had recurrent features throughout the whole of the period. The idea was to delegate the construction of heavy combat vessels to contractors. This fact calls into question the idea that subcontracting primarily concerned secondary vessels, essentially for transport or logistics. On the contrary, from the seventeenth century onwards the aim was to support the mobilization of naval forces with the rapid delivery of numerous vessels and frigates. During the War of the League of Augsburg, construction times were about eighteen months, whereas, a century later, it took a year on average — an achievement that proves the mobilization of trained workers. However, in the midst of war, and excepting contracts that were executed inside arsenals, subcontracting employed labor from the trading ports, insofar as there was any left because the three categories of workers available — maintained, domiciled or conscripted[23] — had generally been taken by the Navy. While the identity of the workers in subcontracting shipyards in the seventeenth century is uncertain because of the lack of

[19] The first technical description of a French war ship dates from a contract of 1639 signed with the Dutch manufacturers at Indret, downstream from Nantes; BNF — *État des dépenses et autres pour la Marine*, 1629-1640, Ms Fr. 6408 fl. 504.
[20] BNF — *Mélanges Colbert 176*, fl. 376, Rochefort, 9 octobre 1670.
[21] The project was handicapped by financial difficulties and a lack of supplies. Laurent Hubac finally succeeded in building five of the ten vessels ordered and the Navy freed him from his commitment in 1667 after the launch of the *Lys* and the *Lionne*, BNF — *Mélanges Colbert 143*, fl. 9, 3 janvier 1667.
[22] ACERRA, 1993: 105.
[23] The «maintained» are those workers listed permanently on the rolls of the arsenal, as against the two other categories who were temporary employees. The «domiciled» workers were those who lived in the town where the arsenal was located and who were recruited whenever the degree of activity so required; in the event of long conflicts, the Navy used conscripted workers living in nearby ports.

precise documentation, this is no longer the case for the eighteenth century. It is worth noting the ability of this civilian workforce to respond to military orders, especially under emergency conditions. By this time, the difference in technical mastery between the arsenals and the civil ports presumed by scholars was in fact not so great.

A feature shared by both of the cases of subcontracting mentioned above, although occurring in different contexts, is that they were applied under the force of circumstances and were not always approved by all of the Navy's officers. On the eve of the American Revolution, the naval commissions set up by the Order of 1776 responsible for overseeing the management of arsenals were still arguing about whether to delegate the construction of naval vessels to contractors. While recognizing the virtues of this formula, and although he approved personally, the Naval Commander of Toulon, Mr. de Saint-Aignan, has left us an account of these debates:

> *In the report of the proceedings of the Naval Commission that I have recently convened and which will be sent with this same letter, you will find certain dissenting opinions from our proposal to contract out shipbuilding and refitting projects, as has already been done with all possible success, but although we are all driven by the same zeal for the good of the service it should come as no surprise that each individual tries to contribute by different means*[24].

This testimony, repeated by many contemporary writers, shows that subcontracting was not the natural choice for the Navy's Secretary of State. Moreover, this reluctance was shared by many other European navies. Even when the Royal Navy subcontracted the majority of its new ships in the second half of the eighteenth century, many of its administrators and officers continued to have reservations. The Earl of Sandwich, who was at the head of the British navy at the time of the American Revolution, stated that when a «vessel of war is subcontracted, a considerable sum is advanced to the shipbuilder […]; if he is not credit-worthy and reliable, he will put off your case and use your money for other purposes [translated here from the French]»[25]. In addition to these financial constraints, there were design faults in some of the vessels ordered from certain shipyards throughout the eighteenth century, and technical aspects that argued against the subcontracting of very large vessels — 100 or more guns — which led the Navy Board to keep the delegation to private contractors for maintenance and repairs to a strict minimum[26].

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[24] AN — *Marine*, B3/632 fls. 5-6, M. de Saint-Aignan, le commandant de la Marine de Toulon, à M. de Sartine, le secrétaire d'État de la Marine, 7 janvier 1776.

[25] BARNES & OWEN, 1932-1938: vol. IV, 293 *apud* KNIGHT, 1998: 57.

[26] KNIGHT, 1974; WEBB, 1988.

In France, the reluctance, or even the hostility, regarding resorting to private enterprise compelled the Secretary of State for the Navy to take charge of the matter in the aftermath of the American Revolution and supervise it more closely. This determination can be seen in the awarding of many contracts for shipbuilding, repairs, and demolitions during the 1780s, followed very closely by the engineers in order to establish a standardized process for future years. This approach of optimization through subcontracting should be seen in the context of profound reforms to military shipbuilding through which the Navy homogenized its fleet by reorganizing its arsenals and establishing standard plans, drawn up by Borda, a scientist, and Sané, an engineer and builder[27]. At the same time, specifications for shipbuilding projects became far more detailed, especially as they would need to be passed on to private companies subcontracted to execute part of future naval programs. The decentralization of shipbuilding to secondary ports would only be effective if a set of technical documents governing the work of the future subcontractors had first been established. It was standard practice in the Navy to draw up different preliminary estimates, but these documents were for internal use for the staff responsible for shipbuilding and the offices of the Secretary of State, which accepted or refused the estimates along with the plans drawn by the engineer-builders.

The challenge was therefore to produce real construction sheets enabling the subcontractor to work without supervision, but by imposing certain materials and construction techniques. In addition, the cost of each model needed to be specified very precisely so that contracts could be awarded at the right price, making the undertaking attractive to both parties. This last point was just as important as the definition of the technical phasing: the Navy needed to be more reasonable than the candidates, who tended to lower their prices excessively in order to win contracts. Too low a price disadvantaged both parties; the subcontractors were unable to fulfil their commitment and at best went bankrupt, or at worst (for the State) might abandon the contract, obliging the Navy to take over the work unprepared with the resulting loss of time and money. In addition, these low prices were obtained in the only area where economies were possible: the construction work itself. The contractor would cut back on working time, inspections would not be carried out thoroughly, and they might not choose the best workers. Finally, many intendants and commissioners in the eighteenth century advanced a further argument: it was important to favor those who provided the State with the best service. A good subcontractor paid fairly tended to offer his services anew, so it was well worth maintaining a pool of partners of proven reliability who could be mobilized all the more easily because they were used to working for the Navy.

[27] ACERRA, 1992.

This unique relationship with private industry, based more on a constructive mutual understanding than on antagonism[28], was crucial for creating a new framework for subcontracting. While most of the new construction specifications were drawn up in 1783, they were considerably modified after the signing of many contracts between 1784 and 1787. The Navy took the opportunity of this period of peace to refine its procedures by relying on seasoned entrepreneurs who took most of the contracts for the smaller units while the ships, frigates, and maintenance work were subcontracted to groups of workers in the arsenals. There is little doubt that this subcontracting was experimental in nature, especially as it was the arsenals of Rochefort, Lorient, and Bayonne that served as laboratories. This meant that any difficulties arising during this type of subcontracting would have had little impact on construction after the American Revolution, because the needs for that war were mostly provided by the arsenals of Brest and Toulon, less affected by this experimental procedure.

In Bayonne, the Navy was involved in constructive talks with Jean-Jacques Casenove, a trader of the city who had been supplying timber to the Arsenal of Rochefort for nearly thirty years when he took on the construction of the *Goéland* and the *Mouche*, two avisos, and the prefabrication of frames for 74-gun vessels[29]. At the Arsenal of Bayonne, Casenove managed all the logistical aspects (supplies, organization of the shipyard), leaving the engineers to concentrate on the different stages of construction. By the end of the eighteenth century, the Navy had long phased the construction of its different models into 24 parts corresponding to a set of predefined tasks[30]. Henceforth, they needed to render this breakdown more intelligible to entrepreneurs, especially as subcontracting was becoming increasingly fragmented with a host of subcontractors behind the prime contractor. However, there were two sides to this optimization, which aimed both to improve conditions for the production of military vessels by third parties and to search for innovations in their construction, as shown in the experiments on prefabrication.

3.TECHNICAL OBJECTS AND SUBCONTRACTORS

From the 1660s and 1670s through to the end of the eighteenth century, shipbuilding contracts changed in form. The resulting documents provide technical and financial details that permit a second level of investigation of naval subcontracting and a closer view of the actors involved and the items manufactured. Before the construction

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[28] The different types of relationship between the world of business and the Navy was complex throughout the eighteenth century, but it is clear that these relationships played an important role in naval innovation: PLOUVIEZ, 2014: 166-171.

[29] SHD — *Marine*, Rochefort, $2G^1$ 14, 1787.

[30] For example, 1/24th and 2/24ths of the construction of a frigate are the following: 1/- Shaping of templates, positioning of keel blocks, work on parts of the keel and their scarphs, attaching the keel assembly to the keel blocks, shaping the bow rail. 2/- Creation, erection, carving of the bow with its apron, shaping and assembling forward main frames on land, shaping the rails for this part of the vessel.

of a ship was entrusted to a third party, a document with costed specifications was always drawn up before the contract, indicating the main characteristics of the vessel to be built. These texts progressively acquired new dimensions and shipbuilding instructions, resulting in a very thick document. This shows how much the Navy's knowledge of the industry was becoming formalized, and probably also a sign of a change in the pool of stakeholders likely to engage in this type of subcontracting. From the War of the League of Augsburg onwards, the «specifications estimate», which was already found in contracts between 1620 and 1640, was associated with a document called a «timbers list», which provided the contractor with information on the choice of raw materials and how to work them. For the seventeenth century, the specifications and timbers list are often the only documents that tell us anything about the work that was actually done, because very few images have come down to us. The exceptions are plans and drawings of details, such as those of the interior layout of the ship or its carvings, «which will be produced by the carpenters and by the arsenal's Master sculptor»[31]. Not until the eighteenth century were construction contracts systematically broken down into articles, starting particularly with the Seven Years' War. At the end of the Ancien Régime, the overall specifications estimate for a ship could consist of two to four separate sets of specifications, corresponding to specific phases of construction. In 1785, the specification for «awarding the labor for the timber and drilling work for the first part of the construction of the King's frigate *Gracieuse* with 26 twelve-pounders»[32] was followed by three others for the second part of the hull, the inner carpentry, and the rigging.

3.1. Naval Shipbuilding and Subcontracting: Interconnected in the Seventeenth Century

For the seventeenth century, it is difficult to assess the nature of the workforce in the shipyards because the documentation says very little about it. In the case of contracts at Toulon at the end of that century, the contractor had to undertake to «employ enough workers»[33] and provide «the days worked by all employees [*i.e.* pay them] for the carpentry, sawing, drilling & for nails and wooden pegs»[34], recurring clauses that are never supplemented with any other information. At first glance, it is easy to imagine that outside workers would be recruited for these subcontracted tasks, precisely to alleviate the burden on their counterparts employed on a regular basis by the arsenals. The civilian part of the port of Toulon had a pool of skilled workers ready to work for the State as long as they were paid. However, it is likely that the arsenal's own workers also participated,

[31] AD 83 — *Marché de construction pour deux vaisseaux*, 22 décembre 1689, 3[E] 5/124 fls. 590-594.
[32] SHD — *Marine*, Rochefort, 2 G[1] 12, *Adjudication de la main d'œuvre des ouvrages de charpente et de perçage nécessaire…*, 12 novembre 1785.
[33] AD 83 — *Marché pour deux brulots*, 6 septembre 1684, 3[E] 5/119.
[34] AD 83 — *Marché pour deux brulots*, 6 septembre 1684, 3[E] 5/119.

especially if that was where the construction took place — an aspect that is never mentioned in contracts at this time.

In addition, even though the workforce was little accustomed to the technical requirements of building military vessels, the presence of the naval shipbuilders among the contractors no doubt helped guarantee optimal management of each construction project. Out of all the contracts identified in a study by Pierre Arnaud, the Navy's own builders appear by name in nearly 50% of them in association with merchants or civilian counterparts. There is also no proof that they were excluded from the other projects. This finding is surprising, because while the Navy's own manufacturers were very often the successful bidders during the period 1630-1660, the various legislative texts, and in particular the Navy Ordonnance of 1689, subsequently banned this practice. Public servants, as these men were, could not become involved in naval business on their own account without the danger of a conflict of interest[35]. However, during the War of the League of Augsburg, this practice still seems to have been common as Blaise Coulomb, Laurent Hubac, and Joseph Ollivier, master-shipbuilders employed by the Navy, were bidders for subcontracts signed at Toulon.

When working as private contractors, these builders were not simultaneously responsible for overseeing the different stages of construction on behalf of the Navy. Thus, when Coulomb was «charged with overseeing the construction of a vessel» being built in Toulon in 1691, he had no financial interest in the work in progress. But was the quality of the ships delivered different in any way? With so few official manufacturers in each arsenal — rarely more than four or five — and in view of the pace of launches in time of war, it seems impossible to rule out collusion or little arrangements between colleagues who at one moment are contractors and the next naval constructors. It is hard to measure the implications of this overlapping between contracting authority and prime contractor, but one thing stands out throughout the seventeenth century: irrespective of the reasons for having recourse to subcontracting in this period, the contractor is a shipbuilder, either French or foreign, practicing this profession either on his own behalf or that of the Navy.

3.2. Entrepreneurship and Navy Supervision of Shipbuilding in the Eighteenth Century

In the eighteenth century, a clearer distinction arises between contractors and shipbuilders, although there were still many exceptions. This was the case with the Dunkerque-based Daniel Étienne Denys (1725-1800) who, while building small vessels for the Navy, in 1771 was granted an honorary title corresponding more or less to junior

[35] The Navy Ordonnance of 1689 indicates the total incompatibility of being both a Naval officer or technician and a business partner, and that any «collusion of interests between administrators and certain entrepreneurs should be avoided». This stipulation is repeated in the Royal Ordonnace of March 13, 1717.

engineer and then, in 1786, that of «ingénieur ordinaire» for the Navy[36]. Jean-Baptiste Lemarchand, a master carpenter from St. Malo, stood out for the quality of his work during the American Revolution and was named junior engineer by the Navy while also continuing to work on behalf of St. Malo shipowners and the State. In the same way, all contracts signed with the workers of the arsenals of Rochefort and Lorient during the 1780s, which are similar to those signed with the master shipbuilders of Toulon at the end of the seventeenth century, continue to blur the distinction between public officials and private enterprise. Nonetheless, most contracts for naval shipbuilding were won henceforth by merchants or businessmen and, while no specific profile emerges, the most effective ones were timber merchants. In Bayonne, Jean-Joseph Casenove had long had experience in timber when he submitted a bid for naval subcontracting. This was also the case for the Arnoul and Bourmaud families in Nantes[37] and La Brillantais-Marion at St. Malo, who «has wit and judgement; he thinks and reflects»[38] according to the engineer-builder Chevillard who oversaw the construction of his frigates. Under the French Revolution and the Empire, Éthéart in St. Malo and the Crucy brothers in Nantes also started their careers selling timber to shipyards or for urban building contracts. Bringing together a varied stock of timber, in which the carpenters were able to find the shapes they needed to create specific parts of the ship's architecture (deck beams, etc.), was essential for the success of a shipyard. It was no coincidence that La Brillantais-Marion managed to launch his frigates in record time while his competitors, all traders and shipowners and with greater financial resources, were regularly forced to interrupt construction for lack of wood of sufficient quantity and quality.

The central role these men occupied tends to push into the background all those directly involved in the actual shipbuilding. Except where internal company archives or correspondence with the engineers supervising the work are available, it is very difficult to get an idea of what the work itself involved. St. Malo's involvement in the American Revolution is a fortunate exception, since the letters and reports of the Naval Commissioner Guinot and the engineer Chevillard, as well as some of the exchanges with the entrepreneurs, enable us to track the day-to-day construction of seven frigates between 1777 and 1778. These documents identify the master carpenters employed on the project, and especially describe their role and their capacity for initiative and inventiveness, under the joint orders of the contractor and the official engineer. In the letters they sent to the Secretary of State for the Navy, Guinot and Chevillard describe their relationship with these men and also provide valuable details on how they worked and how they understood naval architecture. Jean-Baptiste Lemarchand seemed to be the most skillful master carpenter, with Guinot stating that «Master Chevillard has appointed one

[36] DECENCIÈRE, 2014.
[37] CAILLETON, 1999: 105-136.
[38] AN — *Marine*, B3/689 fl. 124, 23 février 1778.

Le Marchand as master shipwright on this contract, on the strength of his knowledge, his talents, his equanimity, his intelligence, his taste for exactitude and his skill in managing his workers»[39]. The identification of this second level of participants, those who are more closely involved in the actual construction, and an analysis of correspondence with the naval authorities, especially the engineers, is fundamental for getting an idea of the technical discussions that must have gone on between civilian and military shipbuilders and that optimized different phases of shipbuilding for the Navy. On this point, we must abandon the idea of insurmountable technical differences between the arsenals and the civilian shipyards. Patrice Decencière, in his study of the plans produced by Denys, argues that this assumption is not valid, as does Bruno Cailleton, who studied civilian shipyards in Nantes in the eighteenth century[40]. The rapid integration of scientific knowledge about shipbuilding by many «civilian»[41] participants and the implementation of solutions for optimizing construction techniques were no doubt of considerable benefit to the Navy when subcontracting. At St. Malo, Chevillard was fascinated by the procedure for launching frigates at low tide and informed the authorities at Versailles of his discussions concerning the use of certain species of wood in the construction, for which he seems to have recommended the practice followed in St. Malo.

Nevertheless, whatever transfers of technical knowledge may have resulted from these collaborative ventures and the acknowledged capabilities of the civilian shipyards, the Navy invested a great deal in supervising the shipbuilding projects it subcontracted during the eighteenth century, as can be seen in its instructions on the employment of the workforce and the visits of its engineers. As in the seventeenth century, the entrepreneurs were free to choose their workers but they were overseen by specialists drawn from Navy's own personnel and seconded to supervise the work. For the construction of two flutes in the port of Bayonne, the contract signed by Casenove stipulates that he:

> *will be given four good carpenters, and two piercers accustomed to the port of Rochefort, particularly to oversee the work and the binding of these flutes, under the supervision of the officers appointed for this purpose, who will ensure that the said plans and specifications are followed faithfully in every respect and will verify that the content of the said inventory is completed, when the said flutes are delivered to the King ready to take to sea*[42].

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[39] AN — B3/679 fl. 25, 26 avril 1777.
[40] DECENCIÈRE, 2014; CAILLETON, 1999.
[41] As an example, at the beginning of the 1780s, Denys calculated the displacement of his vessels using a formula suggested five years previously by CLAIRBOIS, 1776.
[42] SHD — *Marine*, Rochefort, 2 G[1] 10, 10 août 1782.

These men assured optimal supervision of the workers recruited in Bayonne by Cazenove, who were generally unaccustomed to the requirements of military vessel construction, especially as the engineer-builders were not necessarily always on the spot once the plans and the specifications had been handed over to the contractor. The inspection procedures became very restrictive for the contractors but also for the Navy itself, which insisted, for example, on three verifications of the pieces shaped for the hulls. The raw timber had to be inspected before a second inspection following the initial shaping, and finally «after positioning each main part»[43]. When the shipyard was not located in an arsenal but in some distant port, there were not enough engineer-builders to carry out all these inspections, which then fell to the carpenters, drilling specialists, and caulkers seconded for the purpose. Moreover, they were empowered to make inspections at any time, as shown by one contract which specifies that:

> *The maintained master carpenters and the company foremen employed by the day shall follow, under the supervision of the officers appointed for this purpose, the work of the entrepreneurs as regards the accuracy of the work and its robustness, and to ensure no damage is done to the materials used, whose use they shall report to the said officers*[44].

Certain phases of construction were extremely delicate, which increased the responsibility of each of these men accordingly. Where the inspection of the planking was concerned, the caulkers could slow down or suspend the project under way:

> *If, when the caulkers are testing the keel to identify any defects in the planking of the submerged part, they should find parts that need to be repaired, partially or entirely* […] *the contractor shall be obliged to perform this work at his own expense and without any right of redress, since he could always have avoided this expense by inspecting the planking more carefully before installing it*[45].

It is not clear how the master carpenters reported their work to the officers and it is assumed that there are no other documents that explain this technical relationship, which would have been extremely valuable in clarifying just how the subcontracting work proceeded. The registers about those workers, the career records, or the documents by the engineer-builders giving their opinions of the workers would have provided ways of understanding the actual work of these men, whose importance should

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[43] SHD — *Marine*, Rochefort, 2 G[1] 12, *Soumission pour la main d'œuvre de la première partie de la construction d'une frégate portant 26 canons de 12 livres de balle à exécuter au port de Lorient*, 29 septembre 1785.
[44] SHD — *Marine*, Rochefort, *Adjudication de la main d'œuvre de tous les ouvrages de charpente…*, 10 février 1787.
[45] SHD — *Marine*, Rochefort, 2 G[1] 11, *Construction à l'entreprise pour la main d'œuvre de charpentage et de clouage d'une frégate portant du 18*, Brest, 27 octobre 1784.

not be underestimated. In the final analysis, they had much of the responsibility for the proper management of the project, along with the engineers designing the ship, during the construction and especially at the end of the contract, when a visit was systematically organized to judge whether the construction was «good, accurate & of solid execution»[46].

The desire to have a pool of experienced workmen both in the arsenals and in the secondary ports is reflected in the subcontracting documents signed from the 1770s onwards, by which the contractor was obliged to recruit one apprentice for every ten carpenters employed on the project. In addition, for the contracts carried out inside the arsenal, Saint-Aignan, the Commander of the Navy in Toulon during the American Revolution, states that «the contractor should also be required to employ from the Arsenal the good workers, average workers and beginners, which form a source of supply deserving of the utmost care and constantly providing the State with excellent workmen of all kinds»[47]. This condition, found repeatedly in contracts, demonstrated a strategic ulterior motive on the part of the Navy, which hoped to extend the principle of subcontracting to all the ports of the kingdom. The apprentices had the opportunity to work alongside their elders but also with the men seconded from the arsenals who had been brought in to supervise the execution of the work. In this way, the Navy organized the transmission of knowledge at the least cost in preparation for the future.

After this overview, it is clear that the subcontracting of warships in the seventeenth and eighteenth centuries was significant and should be included in any general study on French naval mobilization. While the recourse to subcontracting fitted well with the different imperatives of the period, it can also be said that it organized the technical and business relationship between the Navy and its partners. Before any attempt to analyze this phenomenon, it is essential to historicize this relationship, not only to understand the objects constructed and how the tasks were distributed between the civilian and military participants, but also to identify how know-how might have been exchanged. Whether for hulls launched unfinished, complete ships, or their parts (rigging, interiors, etc.), the administration's choice to build such and such an item was made for a reason. This also provides important information about its ability to respond to the war effort and about the capacity of civilian shipyards to undertake this work. Nevertheless, as we have seen with Toulon during the War of the League of Augsburg and with the circulation of workers from the arsenals in the civilian ports in Bayonne during the 1780s, the borders between public and private shipyards were highly permeable. In addition, it is necessary to compare the objects produced by subcontracting on the European scale. At this stage of research, the low level of interest in this issue among scholars outside France

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[46] SHD — *Marine*, Rochefort, 2 G[1] 14, *Ouvrages à exécuter pour monter* […] *les pièces de quille, étraves, étambot, membrures et lisses du vaisseaux l'Aquilon de 74 canons*, 10 août 1787.

[47] AN — *Marine*, B3/632 fls. 5-6, M. de Saint-Aignan, le commandant de la Marine de Toulon, à M. de Sartine, le secrétaire d'État de la Marine, 7 janvier 1776.

is still a handicap. Little distinction is made between complete ships and parts thereof, to the extent that it is difficult to assess the degree of delegating and to make comparisons. The exceptional preservation of the archives of the British Navy Board, which was responsible for managing construction contracts, should make it possible to answer this question as regards the Royal Navy. In France, an approach to subcontracting via construction contracts alone has limitations that need to be overcome through the use of the Navy's archives of day-to-day events, consisting of letters between intendants, commanders in the ports, engineers, and central offices. If we extend the study to the French Revolution and the Empire, a few valuable collections from private companies should help us approach subcontracting from the point of view of civilian participants, which is much more difficult concerning the Ancien Régime where this type of archive no longer exists.

Finally, while the technical issues are central, a history of subcontracting, whether military or not, must not neglect the economic aspects. What is the financial advantage for a principal to subcontract all or part of an object that it previously manufactured on its own? This aspect has been deliberately set aside at this stage of investigation due to the lack of documentation. There are two difficulties inherent in studying this issue. First, we need to assess the production cost of building a ship in the arsenals and the cost of subcontracting, both in times of peace and of war. Second, we must analyze the productivity of the shipyards: during the American Revolution, the construction time in the State shipyards and in those of the civilian ports were substantially the same despite very different workforces. While the arsenals were able to mobilize brigades of perhaps a hundred carpenters for the construction of frigates, there were only about thirty per ship at St. Malo. In spite of the lacunae in the Navy's accounting records and the complete lack of any for the construction companies, it is still possible to study costs from the reports drawn up by the engineer-builders and administrators, at least from the second half of the eighteenth century.

PRIMARY SOURCES

Archives Départementales de Seine-Maritime

AD 76 — 2^{E} 70-190.
AD 83 — 3^{E} 5/124, fls. 590-594.
AD 83 — 3^{E} 5/119.

Archives Nationales

AN — *Colonies*, F^{3} 158.
AN — *Minutier central des notaires parisiens*, XCVI-14.
AN — *Minutier central des notaires parisiens*, LXXXVI-309, fls. 1-6R.
AN — *Marine*, B3/632, fls. 5-6.
AN — *Marine*, B3/689, fl. 124.
AN — B3/679, fl. 25.

Bibliothèque Nationale de France

BNF — Ms. Fr. 6408, fl. 504.
BNF — Ms. Fr. 6408, fl. 503.
BNF — *Mélanges Colbert 176*, fl. 376.
BNF — *Mélanges Colbert 143*, fl. 9.

Service Historique de la Défense

SHD — *Marine*, Rochefort, *Adjudication de la main d'oeuvre de tous les ouvrages de charpente*…, 10 février 1787.
SHD — *Marine*, Rochefort, $2G^{1}$ 11.
SHD — *Marine*, Rochefort, $2G^{1}$ 10.
SHD — *Marine*, Rochefort, $2G^{1}$ 12.
SHD — *Marine*, Rochefort, $2G^{1}$ 14.

EDITED SOURCES

ACERRA, Martine (1992) — *Les arsenaux français de marine à la fin du XVIII^{e} siècle*. In *Fleurieu et la Marine de son temps, Actes du Colloque de la CFHM, juin 1989*. Paris: Economica, p. 179-189.

——— (1993) — *Rochefort et la construction navale française, 1661-1815*. Paris: Librairie de l'Inde, 4 vols.

BARNES, G. R.; OWEN, J. H., *ed*. (1932-1938) — *The private papers of John, Fourth Earl of Sandwich, 1771--1782*. London: Navy Records Society, 4 vols.

BELLAMY, Martin (1997) — *Danish naval administration and shipbuilding in the reign of Christian IV (1596-1648)*. Glasgow: University of Glasgow. Phd dissertation.

——— (2006) — *Christian IV and His Navy: A Political and Administrative History of the Danish Navy 1596--1648*. Leyde: Brill.

BOWEN, Huw V.; GONZÁLEZ ENCISO, Augustín, *eds*. (2006) — *Mobilising Resources for War: Britain and Spain at Work During the Early Modern Period*. Pamplona: EUNSA.

CAILLETON, Bruno (1999) — *La construction navale civile dans l'amirauté de Nantes au XVIII^{e} siècle*. Nantes: Éditions Hérault.

CASTAGNOS, Pierre (1989) — *Richelieu face à la mer*. Rennes: Éditions Ouest-France.

CLAIRBLOIS, Vial (1776) — *Essai géométrique et pratique sur l'architecture navale*. Paris: A Brest. Available at <https://gallica.bnf.fr/ark:/12148/bpt6k34138720.image>.

CONWAY, Stephen; TORRES-SÁNCHEZ, Rafael, *eds*. (2011) — *The spending of states. Military expenditure during the long eighteenth century: patterns, organisation and consequences, 1650-1815*. Saarbrücken: VDM Verlag.

DECENCIÈRE, Patrice (2014) — *L'élaboration des plans de navire par le construction marchand Daniel Denys à la fin de l'Ancien Régime*. «Neptunia», n.º 275, p. 28-34.

GLETE, Jan (1993) — *Navies and Nations. Warships, Navies and State Building in Europe and America, 1500--1860*. Stockholm: Almqvist & Wiksell International, 2 vols.

——— (2010) — *Swedish Naval Administration, 1521-1721. Resource Flows and Organisational Capabilities*. Leyde: Brill.

GOODMAN, David (1997) — *Spanish naval power, 1589-1665: Reconstruction and Defeat*. Cambridge: Cambridge University Press.

KNIGHT, R. J. B. (1974) — *The performance of the Royal Dockyards in England during the American War of Independence*. In *Proceedings of the 14th Conference of the International Commission for Maritime History*. London, p. 139-144.

_____ (1998) — *Construction et entretien de la flotte anglaise durant les guerres anglo-françaises (1688-1815)*. In ACERRA, Martine; MERINO, Jose; MEYER, Jean, *eds.* — *Les marines de guerre européennes*. Paris: PUPS, p. 47-62.

LAVERY, Brian (1993-1994) — *The Ships of the line*. London: Conway Maritime Press, 2 vols.

LLINARES, Sylviane; HRODEJ, Philippe (2010) — *La mer et la guerre à l'époque moderne*. «Revue d'Histoire Maritime. La recherche internationale en histoire maritime: essai d'évaluation», n.º 10-11, p. 317-356.

MALOUET, Pierre-Victor (1790) — *Rapport sur la dépenses et le régime économique de la Marine*. Paris: Baudoin.

MORRISS, Roger (1983) — *The Royal Dockyards during the Revolutionary and Napoleonic Wars*. Leicester: Leicester University Press.

ORDONNANCE de Louis XIV pour les armées navales et arcenaux de marine. Paris: Estienne Michallet, 1689.

PLOUVIEZ, David (2013) — *Les dynamiques portuaires militaires dans le golfe de Gascogne du XVII^e^ siècle au Premier Empire*. In MARNOT, Brunot; FERNANDEZ, Alexandre, *ed.* — *Les ports du golfe de Gascogne. De Concarneau à La Corogne (XV^e^-XXI^e^ siècle)*. Paris, PUPS, p. 47-60.

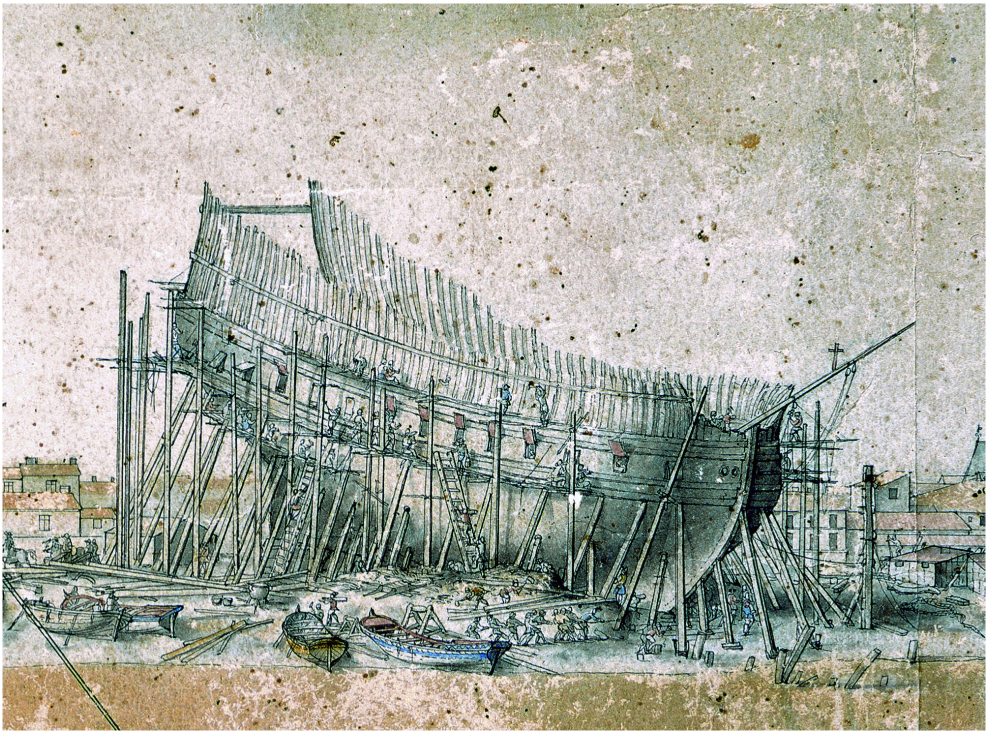
_____ (2014) — *La Marine française et ses réseaux économiques au XVIII^e^ siècle*. Paris: Les Indes savantes.

_____ (2016) — *Introduction*. «Revue d'Histoire Maritime. L'économie de la guerre navale», n.º 22-23, p. 17-26.

THÉVENARD, Antoine (1790) — *Mémoires relatifs à la Marine*. Paris: Laurens.

TORRES-SÁNCHEZ, Rafael (2007) — *The Triumph of the Fiscal Military State in the Eighteenth Century. War and Mercantilism*. In TORRES-SÁNCHEZ, Rafael, *ed.* — *War, Sate and Development Fiscal--Military States in the Eighteenth Century*. Pamplona: Ediciones Universidad de Navarra, p. 13-44.

WEBB, Paul (1988) — *Construction, repair and maintenance in the battle fleet of the Royal Navy, 1793-1815*. In BLACK, Jérémy; WOODFINE, Philip — *The British Navy and the use of Naval Power in the Eighteenth Century*. Leicester: Leicester University Press, p. 207-219.



Appendix 1. Detail of a vessel under construction. A view of the shipyard of Rochefort, showing both vessels and galleys, Nicolas Berquin, 1690. Drawing in pen and black ink, brown and grey wash, watercolor highlights, marouflaged paper on canvas. Source: Musée d'Art et d'Histoire, Rochefort

TIMBER SUPPLYING IN THE SOUTH SPANISH DOCKYARDS DURING THE 18TH CENTURY*

MARÍA AMPARO LÓPEZ ARANDIA

> *The mountains of Segura, as an inland area and far away from dockyards and large populations, remained in the best conditions, even wild. However, other forests closer to those and which can be easily harvested were used to provide the shipbuilding industry, hydraulic and civil architectures with timber. Once those located in the Department of Cartagena* […] *and Cádiz were completely deforested. Thus, the government and timber dealers started cutting down abundantly forests from Seville to Segura, through Jaén, Córdoba, etc., and wrongly thinking that they were exhaustible they took all the pieces of wood required to provide naval dockyards in Cádiz and Cartagena and Andalusia, Mancha, Murcia and some regions of Castile with timber*[1].

INTRODUCTION

The arrival of the Bourbons to the Spanish Crown in the 18th century meant a great development for the maritime industry.

Therefore, different naval dockyards, as Puntales or La Carraca, were established in the South of Spain, near Cádiz, which became a key location for the maritime trading during this century, after the moving of the *Casa de la Contratación*, from Seville, in 1717.

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[1] AMNM — *Sección Maderas*, ms. 436, fl. 109v.

The deforestation of areas located around these dockyards and the increased wood demand led managers of the maritime department of Cádiz to explore the possibilities of harvesting the forests of some inland areas, as those of Segura de la Sierra and its surrounding lands, located at the source of the River Guadalquivir.

After being cut down, the pieces of wood from the forests of Segura were floated down the River Guadalquivir and were received by the dockyards located in Cádiz, some months later.

I shall study these complex processes of timber supplying for the naval construction, which were associated with the creation of a maritime province in the interior of the Iberian Peninsula.

1. THE BOOM OF THE MARITIME INDUSTRY IN THE SPAIN OF THE 18TH CENTURY

The main consequence of the events arising from the War of the Spanish Succession (1700-1714) and the arrival of the Bourbons to the Spanish Crown was to pay more attention to the maritime industry[2].

It was not a new action since some weaknesses related to the Spanish Navy were identified and sought to address in the previous centuries.

In fact, several attempts to reform the Spanish Navy had been made since the 16th century. The first attempt was during the reign of Philip II, which was aimed at acquiring an own royal navy to put an end to the hiring of ships or the use of ships that had previously been seized.

However, the success was limited, mainly because the Monarchy gave priority to the army.

Similarly, important changes were not achieved in the 17th century, even though some actions were taken to promote shipbuilding industry through that century[3], such as the promotion of seats to individuals at the beginning of the century or the establishment, since 1626, of the Superintendences of Shipbuilding and Promotion in Guipúzcoa[4].

The evolution of the war in the early 18th century evidenced the significant weaknesses of the Spanish Navy and highlighted the need of taking more decisive actions on a wide range of aspects such as the shipbuilding industry, in favour of promoting the exaltation of the Navy and the commercial shipping industry. To do so, it was required to develop previous infrastructures like the construction and improvement of ports, like the port in Barcelona, and dockyards[5]. It was also sought to promote the shipbuilding

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[2] CRESPO SOLANA, 2004; IBÁÑEZ DE IBERO, 1943: 184-215; O'DOGHERTY, 1989; O'DONNELL, 2001; RIBOT, 2006.

[3] See VARELA MARCOS, 1988.

[4] GOODMAN, 1997.

[5] DIEGO GARCÍA, 2002.

techniques[6]. A good example of this was the edition of the treatise by Antonio de Gaztañeta, titled *Proporciones de las medidas más esenciales para la fábrica de navíos y fragatas de guerra*, published in 1720[7].

2. CÁDIZ, THE HUB OF THE SPANISH SHIPBUILDING INDUSTRY

During those years, Cádiz became a key point for shipbuilding due to different facts. Some of the main ones were the construction of the dockyards of La Carraca and Puntales[8] and the move of the *Casa de la Contratación* from Seville into Cádiz in 1717. In addition, the General Directorate of the Navy was placed in this city and Cádiz was one of the three maritime departments in which the Iberian Peninsula was organised in 1726.

In fact, the 18th century meant the decline of the dockyards that were the most important until that moment for the Monarchy: those located in Guarnizo[9], Vizcaya and Guipúzcoa[10]. However, it also meant the promotion of those which became the main shipbuilding cores in this century: in the North of Spain, the dockyard of El Ferrol, set up in 1726[11], and in the South, those located in the surrounding areas of Cádiz: La Carraca dockyard, mainly used to repair and careen ships but not so much to build new ships[12], to which was added a new one in 1728, Puntales dockyard. From the following year, 1729, both were operating at full capacity.

A new naval dockyard was opened in the 1730s. It was located in Cartagena, on the Mediterranean coast[13].

The dockyards located near Cádiz went through various difficult times in the 18th century[14]. For instance, after José Patiño[15], the promoter of the creation of La Carraca dockyard[16], died in 1736, this premise was pushed into the background due to the frantic pace of working in the dockyards located in El Ferrol and Cartagena. However, the activity of the naval dockyard of Cádiz experienced a second period of splendour in the 1750s thanks to the drive undertaken by the Marquis of Ensenada. Although shipbuilding was not its main activity, as pointed out above, nearly 23% of the total of vessels and frigates

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[6] TORREJÓN CHAVES, 2002.
[7] CERVERA PERY, 1986: 128-130.
[8] DIEGO GARCÍA, 2002.
[9] CASTANEDO GALÁN, 2001.
[10] ODRIOZOLA OYARBIDE, 1994.
[11] ANCA ALAMILLO, 2003.
[12] QUINTERO GONZÁLEZ, 2000: 133-134.
[13] PÉREZ-CRESPO, 1992.
[14] In the case of La Carraca dockyard, Sánchez-Baena, Chaín-Navarro and Martínez-Solís mentioned two clear periods: one from 1721 to 1751 and another from 1752 to 1796 (SÁNCHEZ-BAENA *et al.*, 2001: 85).
[15] On this person, PULIDO BUENO, 1998.
[16] CRESPO SOLANA, 1994-1995.

built in Spain were built in this dockyard between 1751 and 1765[17]. Its shipbuilding production declined from said year to 1779. It was reactivated again in the 1780s but this time the production was focused on building ships of smaller size. Throughout the 18th century, thirty five vessels were launched from La Carraca dockyard.

3. THE MARITIME PROVINCE OF SEGURA DE LA SIERRA AND TIMBER SUPPLY FOR DOCKYARDS IN CÁDIZ

3.1. Timber in Shipbuilding Industry

Wood was the main raw material used in the shipbuilding industry of the Former Regime. The need for supplying dockyards in Cádiz, in the North of Spain and in Cartagena with huge amounts of wood was a priority for the State, responsible for regulating the supply and shipbuilding processes in dockyards. The Crown promoted visits to mountains since 1717 in order to recognise the forestry potential of certain areas for the development plans for the Navy. We cannot forget the clear image included in the map of the maritime department of Cádiz by Espelius, dated from 1765, where the coat of arms of King Charles III leads the long process from the timber harvesting in forests to the launching of new ships and their floating, through the shipbuilding process[18].

The situation is further complicated if we take into account that the shipbuilding industry required timber with specific characteristics. Firstly, not all tree species were useful for this process[19]. Pine and oak were the two most demanded species in this regard.

Pine was used to build small-size ships like frigates and in linings or interior works of large vessels and was the dominant raw material in the merchant navy[20]. Oak, which was attractive to the Navy because it was a strong and resistant[21] type of wood, was mainly used in the hulls of ships of the line and in frigates.

Mahogany, guaiacum, sabicu, holm oak, black mastic, cedar, black poplar, walnut, beech, cork oak or wild olive tree wood were also used but in lower proportions than those mentioned above[22].

Regarding the timber harvested, the interests of the Navy were very clear. It demanded large pieces of wood, exceeding eight *varas*[23] to avoid joints at all costs. In addition, it was essential to look for pieces of wood that met certain requirements of

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[17] QUINTERO GONZÁLEZ, 2005: 74.
[18] *Mapa o carta corographica que comprehende todas las provincias de Marina, que componen el departamento de Cadiz, reducido de las que en escala mayor se han formado, con Real Orden, por Dn. Joseph Antonio Espelius, capitan del real cuerpo de yngenieros*. Año de 1765. Available at Biblioteca Nacional de España, MR/45 FACS. 24.
[19] In light of this, CABRERA DE AIZPURI, 2008: 16, 116; MELERO GUILLO, 1991: 148.
[20] CHAVES TORREJÓN, 2000: 168.
[21] CHAVES TORREJÓN, 2000: 169.
[22] CHAVES TORREJÓN, 2000: 168.
[23] MERINO NAVARRO, 1981.

shape in order to be used in the different parts of ships[24]. This was reflected by Juan José Navarro, the Marquis of La Victoria, in his work *Diccionario Marítimo*, which is preserved in the Naval Museum of Madrid where many illustrations show these issues in detail[25].

Likewise, wood had to be free from defects not only natural defects including knots, fibre deviation, shakes and parts of deadwood but also defects resulting from a wrong handling before logs got to dockyards, badly cured wood, existence of barks, among others[26].

3.2. Maritime Province of Segura de la Sierra, the Main Source of Timber Supply

> *The region of Segura de la Sierra* […] *located one league away from the River Guadalimar, with a large flow of water, by which the pieces of wood float to arrive in Seville for building vessels*[27].

The dockyards located near Cádiz had to face a big problem from the 1720s. This problem was the deforestation of the closest forests to them, mainly around Cádiz and Seville. This led to go beyond[28]. On the one hand, the idea of importing wood from Flanders and Baltic countries to Seville port had to be rejected due to the high price of the imported timber.

The high quality of wood from Segura de la Sierra was taken into consideration by authorities. Thus, in 1736 it was said about this wood that it was

> *of higher quality than wood from Flanders. Reducing the large amounts which leave Spain every year, it will remain among King's vassals who cut down, transport by road, float down rivers and carry out all tasks required to give to this wood the same perfection as wood from Flanders and even though both are sold at the same price, it is of higher quality and it provides benefits to the Royal Treasury. It also provides advantages for those who would purchase wood to build new factories for the Navy Service and should start to buy it to build ships because it is being cut down*[29].

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[24] CABRERA DE AIZPURU, 2008.
[25] MAESTRO CASTAÑEDA, 2002.
[26] CABRERA DE AIZPURU, 2008.
[27] ESPINALT Y GARCÍA, 1778.
[28] In fact, in 1784, «the declining state of the mountains of that maritime department — Cádiz», as written by Antonio Valdés to Alfonso Alburquerque, in El Pardo, on 17th February 1784, was stressed by maritime department of Cádiz (AMNM — *Colección Vargas Ponce*, tomo XXXVIII, ms. 69, document 112, fl. 113).
[29] AHPS — *Fábrica de Tabacos*, 115, letter from the bishop of Málaga, on 22th May 1736.

On the other hand, the regular purchase of wood mainly from Sierra de Segura and its surrounding areas for shipbuilding industry in the stores of the *Real Fábrica de Tabacos* of Seville as of 1736 led to think that the direct timber harvesting in those forests could be the most appropriate solution to face the high demand of this raw material from the dockyards near Cádiz. The *Real Negociado de Maderas*[30], an entity to govern the supply and sales of wood, was in charge of harvesting timber in said area and transporting it to Seville floating down the River Guadalquivir. In 1738, fifteen thousand one hundred and eighty two pieces of wood were purchased by the naval dockyard[31].

Taking into account these considerations and the fact that timber from Segura had been bought indirectly, i.e., it was purchased through an intermediary, which was the *Real Negociado de Maderas*, those in charge of the maritime department of Cádiz decided to consider the possibility to exploit directly the forests of Segura de la Sierra and its surrounding areas for its own purposes as the *Real Fábrica de Tabacos* of Seville had been doing since 1733.

As a result of this, the maritime department of Cádiz exploring the forests located in Segura de la Sierra in 1738 in order to know directly the conditions and then start felling the area. The results were positive and almost one year later, logs from these forests were being felled and floated down from the source and tributaries of the River Guadalquivir, such as the River Guadalimar, Madera or Trujala, to the dockyards near Cádiz.

Therefore, two different entities had been exploiting the same areas, the forest of Segura and its surrounding areas, since 1739. The two entities were the *Real Negociado de Maderas*, under the authority of the Spanish Secretariat of Treasury, and the maritime department of Cádiz, controlled by the Spanish Secretariat of the Navy.

The most demanded species of wood from the forests in Segura and its surroundings by the dockyards were black pine[32], because of its quality and excellence, and maritime and Aleppo pine that, according to Francisco Gener, one of the managers of the company[33], could be found mainly in the Mountains of Alcaraz, where it was highlighted

[30] An entity founded in 1733 by the Spanish Secretariat of Treasury. This entity was responsible for controlling the timber harvesting in Segura de la Sierra and its surroundings areas, where a branch office was set up to build the *Real Fábrica de Tabacos*. The *Real Negociado de Maderas* was in charge of controlling the process of felling, transporting and use or sales to third parties of timber harvested, even establishing the selling price. In this regard, refer to CRUZ AGUILAR, 1987; LÓPEZ PÉREZ, 2010.

[31] AGS — *Secretaría de Hacienda*, Superintendencia de Hacienda, Maderas de Segura, 849, letter by Francisco Gómez de Barreda to the Marquis of Torrenueva, in Seville, on 21st January 1738.

[32] One of the managers of the maritime province of Segura, Juan Pichardo, pointed out that black pine trees «which grow on the top of the mountains are of higher quality and hardness and they can be used in straight and curved pieces such as yokes, beams and bands», being very useful for the shipbuilding industry (AGS — *Secretaría de Marina*, 576, undated report written by Juan Pichardo).

[33] Francisco Gener was the responsible for monitoring logging and timber floating down the River Guadalquivir under the control of the *Real Negociado de Maderas*. Thanks to his knowledge about shipbuilding, acknowledged by those in charge of the *Real Negociado*, he played a key role in overseeing the timber harvesting for naval dockyards in the years before the harvesting for the *Real Negociado* and the maritime departments was carried out separately. Despite his knowledge and capacity to differentiate pieces of wood for the *Real Fábrica de Tabacos* and for shipbuilding, his

«the large size and the high quality of these species»[34] and that they grew close to the source of the River Guadalquivir, in the district of Cazorla[35].

Ordenanzas para la conservación y aumento de los montes de Marina (Regulations for the preservation and enhancement of mountains of the Navy), known as *Ordenanzas de Montes* (hereinafter Mountain Regulations), were enacted in 1748. This enactment marked a decisive step forward towards the organisation of forests to harvest.

These regulations established the creation of maritime provinces, which were districts controlled by the Secretariat of the Navy, at a lower level than the maritime departments. It was set that maritime provinces were expanded to the mountains located twenty-five leagues away from the coast, although including as well insular mountains and those located inside the Peninsula with navigable rivers[36].

As a direct consequence of this, the Maritime Province of Segura de la Sierra was created. It was one of the inland provinces of Spain because the sources of the River Guadalimar, Guadalquivir y Segura were in this area. It had been found that said rivers were navigable and, therefore, they could be used to transport timber, as it was since 1734 and as it had been even more remotely since the Middle Ages[37].

According to these regulations and due to the interest shown by the shipbuilding industry, the municipal districts of Santisteban del Puerto, Cazorla, Alcaraz and Villanueva del Arzobispo[38] were also added to the area demarcated by the mountains of Segura between 1751 and 1752.

Specially, the maritime province of Segura de la Sierra was an area of almost 9000 km^2, including territories of several legal schemes[39]. It was a particular maritime province in comparison to the other ones not only because it was an inland area but also because it was controlled by two different maritime departments. It was determined

behaviour and perfomance were challenged by the administration. In fact, he was charged with attempting to fraud the Secretariat of Treasury, by claiming that the administration had to pay his son independently, who had been employed in the task of timber harvesting by Gener.

[34] AHPS — *Fábrica de Tabacos*, 115, letter written by Gregorio de la Cruz y Tirado to Sebastián Caballero, in Orcera, on 16th December 1736.

[35] AHPS — *Fábrica de Tabacos*, 115, letter written by Gregorio de la Cruz y Tirado to Sebastián Caballero, in Orcera, on 16th December 1736.

[36] *Los códigos españoles concordados y anotados. Tomo Octavo. Novísima Recopilación de las Leyes de España, tomo II, que contiene los libros quinto, sexto y séptimo*, 1872: book VII, title XXIV, ley XXII, article I, 546.

[37] Some notes in this regard in CÓRDOBA DE LA LLAVE, 1996; 1997; GONZÁLEZ JIMÉNEZ, 2008: 219-221; LAGUNA RAMÍREZ, 1997: 31-32; LINDO MARTÍNEZ, 2008: 79.

[38] AGS — *Secretaría de Marina*, 576.

[39] This demarcation included a small part of territories of the Crown and ecclesiastical seigneuries — territories belonging to the so-called Adelantamiento de Cazorla, dependent on the Archbishop of Toledo, such as Cazorla, La Iruela, Iznatoraf or Villacarrillo, for example. It also included a great number of core areas belonging to the Order of Santiago: Segura de la Sierra, Orcera, Santiago de la Espada, Yeste, Beas, Génave… up to the twenty-one towns — under jurisdictional control until 1748. Finally, these boundaries included localities dependent on secular seigneuries, with territories belonging to the Count of Paredes, such as Villaverde, Riópar, Cotillas, Bienservida and Villapalacios; to the Counts of Balazote — Balazote —; to the House of Santisteban del Puerto, of the well-known lineage of the Benavides, case of Santisteban and Castellar; or belonging to the Count of Arenales, in that of Hinojares. In this regard, LÓPEZ ARANDIA, 2017.

that the mountains with slopes towards the Atlantic Ocean would be integrated in the maritime department of Cádiz and those with slope towards the Mediterranean Sea would depend on the maritime department of Cartagena[40], becoming a special and unique case in the Peninsula[41].

The maritime province of Segura de la Sierra would be delimited as follows: «bordered to the East by the Kingdom of Murcia, to the South by Granada, the East of the Kingdom of Jaén and to the North by the province of La Mancha»[42].

The wealth of the forests located in the maritime province of Segura was undeniable. In fact, the people in charge of the Navy who visited said area highlighted the quality of them. A detailed report released in 1764 outlined the best areas as follows:

> *The mountains of Segura and its surrounding areas are rich in foliage but particularly Calar del Mundo, running to the East, Calar de Naval Peral, Naval Caballero, Collado de las Espumaderas y Oyas de Alva y Díaz, Cintos de Borosa, Royo, Andrés, Fuente del Río, Naval Arna, Naval Espino, Coyado de Gontar, Cuesta del Magano, Cerro del Puerto, Loma del Pelotar, Herrerías, Peñarrubia, Cerro Mirandantre, stream Trapero, las Tres Aguas Expinares; Caídas de la Toba, Garganta Lóbrega, Macegosos, María Asnal; Fuente de la Puerca, el Rico, stream Torno; stream Magullo; stream Canales, hollow of Madera River, from one side to the another one; Poyo de los Caracoles among others which will be extensive to name them*[43].

The estimation performed by the Navy was quite explanatory when it referred to areas like the surroundings of Villamanrique, with more than one million of useful trees for shipbuilding[44]. Similar praises were dedicated to other areas such as Alcaraz by the Secretariat, saying that there were «many millions of pine trees that can be used for shipbuilding and easily transported».

As mentioned above, the most demanded species from the forests of Sierra de Segura and its surroundings was pine. Up to four different species of pine trees grew

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[40] This decision particularly affected the areas of Segura de la Sierra, Alcaraz and El Ballestero, whose surface was distributed between the two slopes and therefore, between the two maritime departments.

[41] For the maritime province of Segura, refer to CRUZ AGUILAR, 1981; LÓPEZ ARANDIA, 2009; RODRÍGUEZ TAUSTE, 2011.

[42] AGS — *Secretaría de Marina*, 576, letter written by Francisco Bruna to the Marquis of Esquilache, in Orcera, on 26th April 1764. An almost exactly the same description in COBO DE GUZMÁN Y LECHUGA, 1994.

[43] AGS — *Secretaría de Marina*, 576, record of mountains of Segura and the Real Negociado of Seville, approved by Order of King Charles III, on 28th May 1764.

[44] AGS — *Secretaría de Marina*, 576, undated document, record of 1778. By contrast, the council of the town, which was opposed to the obligation to be subject to the mountain regulations of 1748 and the rules set forth by the Secretariat of the Navy, claimed that the forests located in this area could not be used for shipbuilding and «may not be certified that logs from here had been sent to this destination or other to defend the kingdom» (AGS — *Secretaría de Marina*, Isla de León, on 16th January 1778). A few months later, this matter was stressed, claiming that in Villamanrique and its surroundings «there was not useful wood for the Royal Service and any tree was cut down to be sent to factories of naval dockyards» (AGS — *Secretaría de Marina*, 576, letter from Antonio de Prado, on the 12th May 1778).

in these mountains: black pine, maritime pine, Aleppo pine and stone pine. The Navy preferences were black pine trees, because timber from this species was the most suitable for manufacturing certain parts of ships such as yokes, beams and bands, and maritime pine trees, because this particular species was lightweight and can float easily on water[45]. Black pine trees grew on the summits of mountains and they can height more than forty *varas*[46], while maritime pine trees, which were smaller, grew on valleys[47] and could reach up to thirty meters in height. By contrast, the Navy rejected felling Aleppo pine[48] and stone pine trees[49].

4. FROM THE MOUNTAINS IN SEGURA TO THE DOCKYARDS IN CÁDIZ

4.1. Works Prior to Floating

Transporting the timber demanded by the dockyards in Cádiz was a difficult task. Those in charge of the process had to deal with various challenges related to it.

Firstly, the large size of logs, exceeding most of the times nineteen or twenty *varas*, and a rough terrain[50] made difficult to transport logs from the place where they had been felled, which were narrow places with lack of space to use a pair of oxen, the means normally used to carry out this activity, to the log ponds located in the headwaters of the Rivers Madera, Trujala, Guadalimar or Guadalquivir. These difficulties often caused

[45] «maritime pine trees are well-proportioned and suitable for any purpose because, although its wood is lighter to float and darker than black pine and stone pine wood, they have much heartwood and they are cut down to make boards, balks and for many other purposes» (AHPS — *Fábrica de Tabacos*, 115, letter from Gregorio de la Cruz y Tirado to Sebastián Caballero in Orcera, on 16th December 1736). In further document, Juan Pichardo stated «they are of high quality, floating and normally smaller than black pine trees» (AGS — *Secretaría de Marina*, 576, undated report written by Juan Pichardo).

[46] A *vara* is an old Spanish unit of length used in the old Castilian system of units. It varied in size at various places, ranging from 768mm (Alicante) to 912mm (Teruel), although the most used was the *vara* from Burgos (836mm). According to the people in charge of the Secretariat of the Navy, the largest volume of black pine trees grew in the area controlled by the maritime department of Cartagena, on the slopes of the River Segura (AGS — *Secretaría de Marina*, 576, undated report by Juan Pichardo). It is a tree species also located in Cuenca, Teruel and Pyrenees foothills (cf. PIQUERAS HABA & SANCHÍS DEUSA, 2001).

[47] AGS — *Secretaría de Marina*, 576, record by Juan Pichardo, undated documents. In the Iberian Peninsula, this tree species can be also found in Albarracín, Cuenca and Guadalajara (cf. PIQUERAS HABA & SANCHÍS DEUSA, 2001).

[48] Aleppo pine trees were not considered to be useful for the people in charge of the Real Negociado de Maderas. Gregorio de la Cruz y Tirado stated «Aleppo pine trees have a limited usefulness because they are not very tall and they have imperfections on logs, their wood is of such a low quality that it can only be used to build structures of wagons and similar items and they do not float due to its hardness». Gregorio de la Cruz y Tirado to D. Sebastián Caballero, in Orcera, on 16th December 1736 (AHPS — *Fábrica de Tabacos*, 115). In a similar description about these trees, the Navy said that «they are useless because they are small and have branches from the bottom» (AGS — *Secretaría de Marina*, 576, undated report by Juan Pichardo).

[49] According to Juan Pichardo, stone pine trees «produce cones and the wood is aimed at smaller-timber» AGS — *Secretaría de Marina*, 576, undated report by Juan Pichardo.

[50] «I really would like you to visit those mountains and areas where the bigger logs grow because they are tangled and rough and notice how hard and expensive is to fell and transport them. They require additional effort by oxen and by people in charge of moving logs, causing fainting to many of them» (AHPS — *Fábrica de Tabacos*, 115, letter written by Gregorio de la Cruz y Tirado to Sebastián Caballero, in Segura, on 21st July 1736).

the refusal of those in charge of transporting to carry out this work. The problem was very obvious when it was needed to transport larger logs, corresponding to topmasts, yardarms and foremasts[51], to log ponds. In fact, those in charge of performed this task considered the works related to timber for dockyards to be «the hardest work»[52].

Likewise, other descriptions we have of the year 1736 are also meaningful in this regard:

> *Last week they started to move* […] *the pieces of wood for the Navy using a wagon and royal wagons and, although the beginnings are always hard, they reached the deepest area of the forests, unloaded there and came back with others belonging to don Gabriel Zorrilla y Nicolás Martínez to be loaded for the dockyard, and I expect that they reach the river today or tomorrow to float timber because although many difficulties have been overcome, the way is not easy and can raise others where logs usually get stuck*[53].

Although those responsible for timber tried to deal with problems when they arose, these incidents emerged as a constant. It was not an easy task.

Some years later, in the visit held in 1764, two new problems were identified. On the one hand, ways from the mountains to the bank of rivers (the River Madera and the River Trujala or directly the River Guadalquivir and the River Guadalimar), where they proceeded to float logs, were in a terrible state of neglect. This meant that people in charge of logging had to go into deeper mountain areas when they considered that there was potential for doing so. On the other hand, certain misuses related to logging and floating processes that had to be improved:

> *ways to drive logs which do not reach the deepest areas of forests were neglected, leaving much useless land with a poor management of the carriage of logs for their floating. It is also identified that much wood is wasted in the pine forest because it is often floated after cutting logs in square shape but if they keep their round shape and only the bark removed, the tasks of cutting will be less hard and faster and there will be more beams to be sold here* […][54].

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[51] AHPS — *Fábrica de Tabacos*, 115, letter written by Gregorio de la Cruz y Tirado to Sebastián Caballero, in Segura, on 10th September 1736. In this case, the situation concerned one hundred and fifty logs which it seemed to be impossible to transport to the log ponds.
[52] AHPS — *Fábrica de Tabacos*, 115, letter written by Gregorio de la Cruz y Tirado to Sebastián Caballero, in Segura, on 19th August 1736.
[53] AHPS — *Fábrica de Tabacos*, 115, letter from Gregorio de la Cruz y Tirado to Mr. Sebastián Caballero, in Segura, on 1st September 1736.
[54] AGS — *Secretaría de Hacienda*, Superintendencia de Hacienda, Maderas de Segura, 849, letter from Mr. Francisco de Bruna to Marquis of Esquilache, in Seville, on 1st February 1764.

As noted above, the interests of the two entities exploiting the area — *Real Negociado de Maderas* bound for the *Real Fábrica de Tabacos* and the Secretariat of the Navy — were completely different. The *Real Negociado* demanded short logs but, on the contrary, the dockyards needed large logs.

The first result of the lack of expertise by individuals responsible for felling and transporting timber, particularly until 1764 when it was determined that the logging of this area was conducted alternatively and annually by the Real Negociado or the naval dockyards located near Cádiz[55] but not both at the same time, was their inability to identify *in situ* the most suitable pieces for the shipbuilding industry. The complaints in this regard were remarkable:

> *regarding the pieces of wood for the Navy, I can assure that it was difficult to match the estimation to the plans given initially by Gener — Francisco Gener[56] —, because now, at the moment of floating logs down the river, it is even more difficult to distinguish them. As we cannot differentiate what a bergamesana, foremast or bowsprit is, I have to go back to the log ponds and ask for someone who could indicate the name of the different pieces of wood in order to classify them[57].*

Over time to monitor the logging, the maritime department of Cádiz set up a committee of timber harvesting for building ships for the Navy which remained operational until 1816[58]. In this year, there was a discussion on whether this committee had to be the only entity responsible for harvesting, felling and transporting the required wood to Seville and the naval dockyards[59].

Likewise, the difficulties followed one another when timber had to be driven through watercourses, a situation which depended, to a large extent, on the weather conditions. In fact, timber floating was hampered, even prevented, due to the lack of water some years and due to the excess of water or heavy rainfalls other years. Regarding this, in 1788 those in charge of felling pointed out that the timber shipments for the *Real Negociado de Maderas* and for La Carraca naval dockyard had to be cancelled two

[55] In 1816, there was a discussion on suspending this provision in force as of 1764, establishing that each entity shall cut down, on an annual basis, the half of trees consisting of the pine forest, in favor of one of the two institutions which had been damaged because it could not fell trees in the corresponding year (AMNM — *Sección Maderas*, ms. 436, 1816, report on maintaining the Committee for felling timber for the Royal Navy, fls. 108 v-109 r).
[56] AHPS — *Fábrica de Tabacos*, 117, letter from Gregorio de la Cruz y Tirado to Mr. Francisco Gómez de Barreda, in Orcera, on 31th August 1737.
[57] AHPS — *Fábrica de Tabacos*, 115, letter from Gregorio de la Cruz y Tirado to Mr. Sebastián Caballero, in Orcera, on 16th December 1736.
[58] AMNM — *Sección Maderas*, ms. 436, fl. 107 r.
[59] AMNM — *Sección Maderas*, ms. 436, fl. 108 r.

years and three years respectively, due to the lack of water in the Rivers Guadalimar and Guadalquivir[60].

People in charge of transporting logs, therefore, had often to look out for the appropriate weather conditions to float logs down the river. This is shown in the words said in 1737 by those responsible for transporting wood, who

> *are worry about these pine trees, particularly the logs for the Navy* […] *because (according to the locals) they are the biggest pieces that have gone down the River Guadalimar* […] *it is hope that God sends enough water to make bigger logs float because it is estimated that the biggest ones require ¾ or more water to go downstream and the higher amount of water the river has, safer the floating of wood is. As the main difficulties, problems and hassle can arise from the log ponds to the entrance of the River Guadalquivir, we hope that His Majesty desires that the river has enough water to get there and we can overcome other obstacles we may find*[61].

The challenging process from timber felling to floating lasted several months. Trees used to be cut down in March, once the coldest winter months had passed, being particularly hard in this maritime province due to the frequent snowfalls. However, at the end of the 18th century, felling was moved to January and August because they were considered the most suitable months to cut down trees because there was no circulation of sap in them[62].

Indeed, in the 1730s there was a discussion on the best season to cut down trees. It was considered that trees were at their best for felling at the end of August or September:

> *felling in August is a good idea because the sap starts going down and keeps on lowering until January and February. Thus, the best felling will be the one carried out in this month (September) and in the following months and felling made in winter where trees get frozen due to the cold, rainfalls and snowfalls and do not get rid of rain and be heavy for navigation are shared only*[63].

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[60] AGMAB — *Arsenales*, 3785, letter from Juan Pichardo to Manuel Bernia, in Orcera, on 30th April 1788. Some months later, Manuel Bernia kept on insisting on this issue: five floats had to be cancelled, two of them were for the *Real Negociado* and the other three ones were for La Carraca. *Ibidem*, letter written by Manuel Bernia to Juan Pichardo, on 16th May 1788.

[61] AHPS — *Fábrica de Tabacos*, 116, letter from Gregorio de la Cruz y Tirado to Mr. Francisco Gómez de Barreda, in Orcera, on 7th September 1737.

[62] DUHAMEL DU MONCEAU, 2009 and MUÑOZ, 1825.

[63] AHPS — *Fábrica de Tabacos*, 115, letter written by Gregorio de la Cruz y Tirado to Sebastián Caballero, in Segura, on 10th September 1736.

After felling, the pieces of wood used to remain outdoors, placed on rollers or boards, allowing ventilation and drying to lose resin[64], a key process to facilitate timber floating.

Then, between September and October, the pieces of wood were transported to log ponds. Finally, in November and December, when the rainy season came, floating wood on watercourses started[65].

Timber harvesting for the *Real Negociado de Maderas* and the naval dockyards located in the South of Spain was the main source of income for those who lived around this area because, as pointed out by the maritime department of Cádiz in 1816, over two thousand of men were employed directly or indirectly in this activity[66].

4.2. Floating Logs Down the River Guadalquivir to Cádiz

From Segura and its surrounding areas, pine timber was floated down the Rivers Trujala, Madera, Guadalimar or Guadalquivir to be driven through the latter river to Seville. From Seville, this timber was transported by light carriage or cart to the naval dockyards located near Cádiz[67].

According to Merino Navarro, an amount between three thousand and six thousand logs was driven through the River Guadalquivir every year[68]. Nevertheless, the exact amount of pieces of wood from the maritime province of Segura de la Sierra received by the dockyards located in Cádiz is unknown due to the lack of information in this regard. It must be noted that in most of the cases, the documents preserved refer to figures of pieces of wood shared by the *Real Negociado* and the Navy so not all the pieces were for naval dockyards. Furthermore, although there is data available from 1764, year in which timber harvesting started being carried out alternatively and independently, we do not know which entity managed the felling each year.

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64 ÁLVAREZ NOVER & FERNÁNDEZ-GOLFÍN SECO, 1992.

65 AGS — *Secretaría de Marina*, 576. Some very general notes about the timing of the process in MARTÍNEZ RUIZ, 1996: 33-34.

66 AMNM — *Sección Maderas*, ms. 436, fl. 111 v.

67 General references in ARAQUE JIMÉNEZ, 2008: 17-18; VIGUERAS GONZÁLEZ, 2002; YDÁÑEZ DE AGUILAR, 1999. Although in this study we focus on log driving through the River Guadalquivir, we should not forget that at the same time, logs were being floated down the River Mundo and Segura to supply the dockyard in Cartagena with timber. Refer to LÓPEZ ARANDIA, 2012.

68 MERINO NAVARRO, 1981: 203.

Table 5.1. Timber driven through the River Guadalquivir (18th century)

Year	Number of pieces
1734	8,000
1738	15,182
1751	14,000
1760	9,000
1763	3,697
1764	6,017
1765	9,319
1766	6,750
1769	4,960
1776	2,024
1780	7,000
1783	3,431
1786	7,110
1796	3,927

Source: Table by the author

Among the limited data available, we know that managers of the pine forests stated that a «large amount» of logs were cut down in 1737 and over one thousand five hundred of the total pieces were received by the Navy[69]. However, the exact amount is unknown; this is why it was not included in the table. We also know that in 1783, three thousand seven hundred and ninety four of pine trees were cut down by the Navy and driven through the River Guadalquivir. However, due to heavy rainfalls two thousand one hundred and twenty one pieces only reached the naval dockyard[70]. The figures of these two distant years lead us to believe that the pieces of wood for the naval dockyards in Cádiz may never be less than at least a thousand.

Given the irregular flow of rivers, the floating method used was to float logs separately. This method required specific conditions to transport timber. Therefore, smaller pieces of wood were used when bigger pieces of wood were driven through rivers. These smaller pieces were used in the course of floating to facilitate the transport of the biggest ones. The amount of smaller pieces used increased, reaching a considerable number:

[69] AHPS — *Fábrica de Tabacos*, 116, Juan Gallego to Sebastián Caballero, in Úbeda, on 12th February 1737.

[70] AGMAB — *Maderas*, 3767, letter written by Juan Antonio Enríquez to Antonio Valdés, in Seville, on 3rd January 1784. Enríquez stated that a thousand twenty three pieces had been lost. A few days later, he increased the figure of lost pieces up to a thousand eighty three, being «very good pieces of wood of 20-24 inches and 20-24 cubits in length and due to they are pieces suitable for big vessels and frigates, I consider they can cost around two millions of *reales* each». *Ibidem*, Juan Antonio Enríquez to Francisco de Banzes, in Seville, on 10th January 1784.

> *To drive down the river, beams of 10-16 cubits in length were cut and, although they are not very useful for the Navy, they facilitate the transport. This leads to increase the number of them, but luckily the last shipment required less than 1500 beams*[71].

Although the smaller pieces of wood had not a clear use in dockyards, they were used in other activities or even sold to third parties.

Logs were driven by people known as *pineros* (log drivers) or *gente de gancho*. Organised in crews, they were responsible for accompanying logs along the banks of the River Guadalquivir, preventing logs from get stranded on riverbanks and helping to overcome stretches of the river such as dams, bridges and mills.

Log drivers were often organised in big groups over fifty men[72]. These men came from towns near Segura de la Sierra and some of them from Córdoba. They used to work for long months, averaging between six or seven months, although they sometimes had to work nine months[73] in log driving. Besides log drivers, crews also counted with the collaboration of other workers who performed equally important tasks to ensure the survival of the group, including muleteers, cattle herds, stewards and stewards' assistants and servants, experts in rivers and even priests[74].

Table 5.2. Number of log drivers who worked through the River Guadalquivir

From	Year			
	1739	1740	1742	1743
Beas de Segura	9	1	4	8
Benatae	—	1	—	
Benttarique	—	—	—	1
Córdoba	17	13	13	22
Hornos	—	—	—	3
Quesada	—	1	—	—
Orcera	6	3	2	13
Puerta de Segura	—		1	2
Santo Tomé	—	—	—	1
Segura	—	2	—	2

[71] AGS — *Secretaría de Marina*, 576.
[72] It is well above the dozen of members of crews pointed out by Ydáñez de Aguilar. Refer to YDÁÑEZ DE AGUILAR, 1999: 318.
[73] AHPS — *Fábrica de Tabacos*, 96, record book of log drivers, 1743.
[74] AGS — *Secretaría de Marina*, 576.

From	Year			
	1739	1740	1742	1743
Úbeda	41	28	19	19
Villahermosa	1		—	
Villanueva del Arzobispo	68	11	33	35
Yeste	—	—	—	1
N/A	6	—	—	1
Total	148	50	72	108

Source: AHPS — *Fábrica de Tabacos*, 94 and 96; table by the author

Driving logs by the River Guadalquivir was not an easy work, particularly when the destination of timber was the dockyards in Cádiz. The big size of the pieces of wood required and, therefore, their heaviness were obstacles for log drivers' work because logs were at risk of sinking in the river[75] and delayed the navigation when it was necessary to go through stretches. Thus, sometimes, when big logs led to many problems due to their big size and heaviness, they were taken out of rivers and left on the banks of rivers[76].

Weather events impacted adversely in log driving in previous moments of floating logs. These events could be years of drought, when the lack of water prevented from floating, or flooding that often caused the dispersion of logs floating[77]. Thus, heavy rainfalls in 1784, for instance, resulted in the dispersion of logs for La Carraca dockyard once they got to Seville. The first logs were found in Dos Hermanas, Las Cabezas[78] and even close to Sanlúcar de Barrameda[79] and over one thousand of logs could not be found, in

[75] AHPS — *Fábrica de Tabacos*, 96, letter written by Francisco Gómez de Barreda, in Seville, on 31st May 1743.

[76] AHPS — *Fábrica de Tabacos*, 94, Libro en que ban las quentas de los pineros… 1739. Likewise, AHPS — *Fábrica de Tabacos*, 96, document written by Gregorio de la Cruz y Tirado, in Andújar, on 15th May 1739, reporting that one hundred and seventy one pieces were taken out of the river because they were very heavy; document by Andrés García de Rojas y Juan González Galán, in Andújar, on 14th July 1740.

[77] AGS — *Secretaría de Marina*, 576. We found a clear description of this situation in 1776. The governor of the maritime department of Cádiz was informed on the need of specific conditions to float logs down the river and how the lack or excess of water impact on it: «in the first case, the navigation is stopped and in the last case, flooding causes the dispersion of logs and at the expense of great efforts, costs and waste of time, they have to be returned to the centre of the river to continue». It was written to the governor of Cádiz to inform him on the state of logs from Segura, in San Lorenzo, on 15th November 1776.

[78] AGMAB — *Maderas*, 3767, information written by the commissioner Juan Antonio Enríquez to Antonio Valdés, in Seville, on 17th January 1784.

[79] *Ibidem*, document by the governor Juan de Ulloa to Antonio Valdés, in Isla de León, on 23rd January 1784.

particular one thousand twenty three[80] of a group of three thousand seventy hundred and ninety four pieces at the beginning[81].

After arriving in Seville, logs were unloaded in an area near the current bridge of Isabel II, known as Bridge of Triana, and from that point they were transported by light carriage[82] or by cart to the naval dockyards of La Carraca and Puntales.

Timber from the maritime province of Segura de la Sierra was essential and vital for the Navy, as pointed out by the managers of the department of Cádiz in 1816, when they held that the Navy «does not have other forests to supply La Carraca with such a high quality pine timber»[83].

CONCLUSIONS

The arrival of the Bourbons to the Spanish Crown meant the promotion of important reforms in the Navy that led to a boom in shipbuilding industry for merchant vessels and warships.

Some of these centres were located in the South of Spain, particularly in the naval dockyards of La Carraca and Puntales, which became two of the main centres for building and repairing ships in the 18th century, an activity that reached its peak in the second half of the century.

Thus, the demand of timber, the main raw material for the shipbuilding industry, increased significantly.

However, the lack of timber in areas surrounding the naval dockyards located near Cádiz required looking for wood from inland areas and where there had already been a tradition of timber harvesting for uses like civil building industry and that had been used occasionally to provide the naval dockyards. One of these areas was the mountains of Segura de la Sierra.

The enactment in 1748 of the Regulations of Mountains granted certain areas, such as Segura, the maritime province status. Therefore, its jurisdiction started depending on the Spanish Secretary of the Navy. This fact strengthened the relationship between this space and naval dockyards like La Carraca.

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[80] It was also written that the total amount of logs lost due to a flash flood was of one thousand eighty three logs of «high quality, between twenty and twenty four inches and between twenty and twenty four cubits of length that are very appreciated to be used for beams of the wheelhouse thanks to their natural features. I estimate that the costs are around two thousand million of *reales*». *Ibidem*, written by Juan Antonio Enríquez to Francisco de Banzes, in Seville, on 10th January 1784.

[81] «However, before dawn on the first day of this month, when the bridge (Bridge of Triana) was already broken, it was such the strength of the water that breaking noisily the chains and hawsers of it, it swept away by in the flood, with nine of its ten ships, which have no anchors, and these and other ships crashed into the thousands of them». *Ibidem*, document sent by Juan Antonio Enríquez to Antonio Valdés, in Seville, on 3rd January 1784.

[82] AGMAB — *Arsenales*, 3785.

[83] AMNM — *Sección Maderas*, ms. 436, fl. 111 r.

As a result, the River Guadalquivir became a decisive way for driving big logs from the forests of inland areas to the South of Spain through a challenging and hard process full of difficulties.

PRIMARY SOURCES

Archivo del Museo Naval de Madrid
AMNM — *Sección Maderas*, ms. 436.
AMNM — *Colección Vargas Ponce*, t. XXXVIII, ms. 69, d. 112.

Archivo General de la Marina Álvaro de Bazán
AGMAB — *Arsenales*, 3785.
AGMAB — *Maderas*, 3767.

Archivo General de Simancas
AGS — *Secretaría de Hacienda*, Superintendencia de Hacienda, Maderas de Segura, 849.
AGS — *Secretaría de Marina*, 576.

Archivo Histórico Provincial de Sevilla
AHPS — *Fábrica de Tabacos*, 94.
AHPS — *Fábrica de Tabacos*, 96.
AHPS — *Fábrica de Tabacos*, 115.
AHPS — *Fábrica de Tabacos*, 116.
AHPS — *Fábrica de Tabacos*, 117.
LOS CÓDIGOS ESPAÑOLES concordados y anotados. Tomo Octavo. Novíssima Recopilación de las Leyes de España, tomo II, que contiene los libros quinto, sexto y séptimo. Madrid: [s.n.], 1872.
MAPA O CARTA corographica que comprehende todas las províncias de Marina, que componem el departamento de Cadiz, reducido de las que en escala mayor se han formado, con Real Orden, por Dn. Joseph Antonio Espelius, capitan del real cuerpo de yngenieros, año de 1765. Available at Biblioteca Nacional de España, MR/45 FACS. 24.

EDITED SOURCES

ÁLVAREZ NOVER, Humberto; FERNÁNDEZ-GOLFÍN SECO, Juan Ignacio (1992) — *Fundamentos teóricos del secado de la madera*. Madrid: Ministerio de Agricultura, Pesca y Alimentación.
ANCA ALAMILLO, Alejandro (2003) — *Jorge Juan y el Arsenal de El Ferrol*. Madrid: Fundación Jorge Juan.
ARAQUE JIMÉNEZ, Eduardo (2008) — *El río primero: de sus orígenes a Montoro*. In RUBIALES TORREJÓN, Javier, *ed.* — *El río Guadalquivir*. Sevilla: Junta de Andalucía – Ministerio de Medio Ambiente, p. 17-18.
CABRERA DE AIZPURU, Fernando (2008) — *Arquitectura naval europea en el siglo XVIII*. La Coruña: Universidad de La Coruña.
CASTANEDO GALÁN, Juan M. (1993) — *Guarnizo, un astillero de la Corona*. Madrid: Editorial Naval.
CERVERA PERY, José (1986) — *La Marina de la Ilustración*. Madrid: Editorial San Martín.
CHAVES TORREJÓN, Juan (2000) — *La madera báltica, Suecia y España (Siglo XVIII)*. In RAMOS SANTANA, Alberto — *III Encuentro Histórico Suecia-España. Comercio y navegación entre España y Suecia (Siglos X-XX)*. Cádiz: Universidad de Cádiz, p. 163-222.

COBO DE GUZMÁN Y LECHUGA, Jesús (1994) — *Estudio sobre las ordenanzas de montes del año de 1748 y del expediente sobre el régimen de administración de los montes de Segura de la Sierra y de su Provincia Marítima, 1811*. Jaén: Caja de Jaén.

CÓRDOBA DE LA LLAVE, Ricardo (1996) — *La red hidrográfica y su incidencia sobre las comunicaciones por el término de Córdoba durante el siglo XV*. In CRIADO DE VAL, Manuel, *dir.* — *Caminería hispánica. Actas del II Congreso Internacional de Caminería Hispánica*. Madrid: Patronato Arcipreste de Hita — Asociación Técnica de Carreteras, tomo II, p. 227-231.

_____ (1997) — *Navegación y transporte fluvial en la Península Ibérica a fines de la Edad Media*. In CRIADO DE VAL, Manuel, *dir.* — *Caminería hispánica. Actas del III Congreso Internacional de Caminería Hispánica*. Madrid: AACHE Ediciones, p. 215-233.

CRESPO SOLANA, Ana (1994-1995) — *La acción de José Patiño en Cádiz y los proyectos navales de la Corona del siglo XVIII*. «Trocadero», vol. 6-7, p. 35-49.

_____ (2004) — *La reforma de la Marina española en tiempos de Felipe V: luces y sombras de un debate historiográfico*. «Revista Universitaria Mágina», vol. 12, p. 11-24.

CRUZ AGUILAR, Emilio de la (1981) — *La Provincia Marítima de Segura de la Sierra*. «Boletín del Instituto de Estudios Giennenses», n.º 107, p. 51-82.

_____ (1987) — *El Negociado de Maderas de Segura en Sevilla*. «Historia, Instituciones y Documentos», n.º 14, p. 51-82.

DIEGO GARCÍA, Emilio de (2002) — *Estructuras de la organización naval: departamentos y arsenales peninsulares*. In *XXVI Jornadas de Historia Marítima. Arsenales y construcción naval en el siglo de la Ilustración*. Madrid: Instituto de Historia y Cultura Naval, p. 15-39.

DUHAMEL DU MONCEAU, Henri Louis (2009) — *Tratado del cuidado y aprovechamiento de los montes y bosques, corta, poda, beneficio y uso de sus maderas y leñas*. Maxtor: Valladolid.

ESPINALT Y GARCÍA, Bernardo *et al.* (1778) — *Atlante español o descripcion general de todo el reyno de España*. Madrid: Imp. de Pantaleon Aznar, tomo 1, p. 213-214.

GONZÁLEZ JIMÉNEZ, Manuel (2008) — *El Guadalquivir medieval*. In RUBIALES TORREJÓN, Javier, *ed.* — *El río Guadalquivir*. Sevilla: Junta de Andalucía – Ministerio de Medio Ambiente, p. 213-221.

GOODMAN, David (1997) — *Spanish naval power, 1598-1665. Reconstruction and defeat*. Cambridge: Cambridge University Press.

IBÁÑEZ DE IBERO, Carlos (1943) — *Historia de la Marina de Guerra española. Desde el siglo XIII hasta nuestros días*. Madrid: Espasa-Calpe.

LAGUNA RAMÍREZ, María (1997) — *El Guadalquivir y Córdoba en el Antiguo Régimen. Navegación, conflictos sociales e infraestructura económica*. Córdoba: Universidad de Córdoba.

LINDO MARTÍNEZ, José Luis (2008) — *Castilla — La Mancha. Maderadas y gancheros*. Toledo: Junta de Comunidades de Castilla – La Mancha.

LÓPEZ ARANDIA, Maria Amparo (2009) — *El mar en el interior. La provincia marítima de Segura de la Sierra*. In DUBERT, Isidro; SOBRADO CORREA, Hortensio, *eds.* — *El mar en los siglos modernos*. Santiago de Compostela: Xunta de Galicia, vol. I, p. 437-450.

_____ (2012) — *Maderas del rey. Aprovechamientos madereros en la provincia marítima de Segura de la Sierra*. In ARAQUE JIMÉNEZ, Eduardo; MOYA GARCÍA, Egidio, *eds.* — *Aprovechamientos madereros en los montes jiennenses (siglos XVIII-XX)*. Jaén: Universidad de Jaén, p. 13-78.

_____ (2017) — *Territorio vs. Estado. Nuevas fronteras y conflictos en la España del siglo XVIII*. In FAVARÒ, Valentina; MERLUZZI, Manfredi; SABATINI, Gaetano — *Fronteras: procesos y prácticas de integración y conflictos entre Europa y América (siglos XVI-XX)*. Madrid: Fondo de Cultura Económica, p. 265-285.

LÓPEZ PÉREZ, Elena (2010) — *Dos documentos sobre el Real Negociado de Maderas y la Provincia Marítima de Segura, conservados en el Archivo Histórico Provincial de Jaén*. «Arch-e. Revista Andaluza de Archivos», n.º 3, p. 133-142.

LOS CÓDIGOS españoles concordados y anotados. Tomo Octavo. Novísima Recopilación de las Leyes de España, tomo II, que contiene los libros quinto, sexto y séptimo. (1872) Madrid: Antonio de San Martín editor.

MAESTRO CASTAÑEDA, Juan Carlos (2002) — *D. Juan José Navarro, marqués de La Victoria: entre reformista y resentido*. «Brocar», n.º 26, pp. 177-190.

MARTÍNEZ RUIZ, Enrique (1996) — *Tres sierras, tres culturas. Acabemos con los incendios forestales en España*. Madrid: Ministerio de Agricultura.

MARURI VILLANUEVA, Ramón (2001) — *Ensenada y el Real Astillero de Guarnizo*. «Brocar», vol. 25, p. 123-136.

MELERO GUILLO, Maria Jesús (1991) — *«A la mar madera»: la madera en la arquitectura naval española*. In RAMÍREZ, Bibiano Torres, *coord*. — *Andalucía América y el mar: Actas de las IX Jornadas de Andalucía y América*. Sevilla: Diputación de Huelva.

MERINO NAVARRO, José (1981) — *La armada española en el siglo XVIII*. Madrid: Fundación Universitaria Española.

MUÑOZ, Tomás (1825) — *Expediente sobre el régimen y administración de los montes de Segura de la Sierra y su provincia*. Madrid: Miguel de Burgos.

O'DOGHERTY, Pascual (1989) — *La construcción naval en la Península*. In PALACIO ATARD, Vicente, *coord*. — *España y el mar en el siglo de Carlos III*. Madrid: Marinves, p. 93-94.

O'DONNELL, Hugo (2001) — *La Marina durante el primer reinado de Felipe V (1700-1724)*. In CASTAÑEDA DELGADO, Paulino; GÓMEZ PIÑOL, Emilio, *coord*. — *La Guerra de Sucesión en España y América. Actas X Jornadas Nacionales de Historia Militar*. Seville: Deimos, p. 439-449.

ODRIOZOLA OYARBIDE, María (1994) — *La industria naval guipuzcoana (1650-1730): ¿crisis o auge del sector?*. In GÁRATE, Monserrat; MARTÍN ACEÑA, Pablo, *eds*. — *Economía y empresa en el Norte de España. (Una aproximación histórica)*. San Sebastián: Universidad del País Vasco.

PÉREZ-CRESPO, María Teresa (1992) — *El arsenal de Cartagena en el siglo XVIII*. Madrid: Editorial Naval.

PIQUERAS HABA, Juan; SANCHÍS DEUSA, Maria del Carmen (2001) — *El transporte fluvial de madera en España*. Geografía histórica. «Cuadernos de Geografía», n.º 69-70, p. 127-161.

PULIDO BUENO, Ildefonso (1998) — *José Patiño: el inicio del gobierno político-económico ilustrado en España*. Huelva: Artes Gráf. Andaluzas.

QUINTERO GONZÁLEZ, José (2000) — *El arsenal de La Carraca (1717-1736)*. Madrid: Ministerio de Defensa.

_____ (2005) — *El arsenal de La Carraca en Cádiz durante el siglo XVIII*. «Andalucía en la Historia», vol. 8, p. 69-75.

RIBOT, Luis (2006) — *Las reformas militares y navales en tiempos de Felipe V*. In MAZA ZORRILLA, Elena; DEL OLMO MARCOS, María, *coords*. — *Estudios de Historia. Homenaje al profesor Jesús María Palomares*. Valladolid: Universidad de Valladolid, p. 129-161.

RODRÍGUEZ TAUSTE, Sergio (2011) — *La Provincia Marítima de Segura de la Sierra. Siglos XVIII-XIX*. In ARAQUE JIMÉNEZ, Eduardo; MOYA GARCÍA, Egidio, *eds*. (2012) — *Aprovechamientos madereros en los montes jiennenses (siglos XVIII-XX)*. Jaén: Universidad de Jaén, p. 79-124.

SÁNCHEZ BAENA, Juan; CHAÍN NAVARRO, Celia; MARTÍNEZ-SOLÍS, Lorena, *coords*. (2001) — *Estudios de Historia Naval. Actitudes y medios en la Real Armada del s. XVIII*. Murcia: Ministerio de Defensa — Universidad de Murcia.

TORREJÓN CHAVES, Juan (2002) — *La construcción naval militar española en el siglo XVIII: tendencias, programas y constructores*. In *XXVI Jornadas de Historia Marítima. Arsenales y construcción naval en el siglo de la Ilustración*. Madrid: Instituto de Historia y Cultura Naval, p. 131-180.

VARELA MARCOS, Jesús (1988) — *La pretendida reforma naval de Felipe III: La política de protección de bosques, saca y elaboración de maderas para la construcción naval.* «Revista da Universidade de Coimbra, Centro de Estudos de História e Cartografia Antiga», vol. 34, Offprint.

VIGUERAS GONZÁLEZ, Modesto (2002) — *El transporte de madera por flotación y carretería, desde los bosques de Sierra de Segura hasta Sevilla y los arsenales de La Carraca (Cádiz) y Cartagena, durante los siglos XVIII y XIX (1734-1833).* Madrid: Puertos del Estado.

YDÁÑEZ DE AGUILAR, Alejandro Faustino (1999) — *El transporte fluvial de la madera de los montes de Jaén*. «El Toro de Caña», n.º 4, p. 305-325.

SHIPBUILDING, KNOWLEDGE, TECHNOLOGY AND HERITAGE PORTUGUESE SHIPBUILDING & LOW COUNTRIES PRACTICES: IBERIAN INFLUENCES IN THE DUTCH GOLDEN AGE

RICHARD W. UNGER

INTRODUCTION

Dutch shipbuilding established the standard for quality in seventeenth-century Europe. By any measure its example was the one to copy. The Dutch Republic in the seventeenth century was the envy of all of Europe. Most obviously to contemporaries the economy thrived on the expansion of shipping. It was Dutch shipbuilders who supplied the vessels for the success that was a cornerstone of the most prosperous economy in Europe and probably the world at the time. «The advantages gained by cheap and adaptable shipbuilding, and cheap and careful navigation, were summed up in the lowest freight rates in Europe, and the most extensive and efficient merchant marine»[1]. Historians have written a great deal more about the roots of Dutch economic success since the publication of Barbour's powerful claim[2]. There were many other sources of Dutch success, however, superior transportation on the water, whether rivers, canals, lakes or the high seas, remains critical to any explanation for the prosperity of the Golden Century and the sustained high levels of income down to the end of the eighteenth century. Even if historians raise some questions about the relative importance of shipping and shipbuilding people in seventeenth-century Europe were in no doubt. Foreigners bought Dutch ships, even entrepreneurs from a major port and long-time centre of shipbuilding as Venice. Others tried to capture Dutch ships to add those vessels

[1] BARBOUR, 1930: 285.
[2] For example and among many others, DE VRIES & WOUDE, 1997; ZANDEN, 1993; PRAK & WEBB, 2005.

to their merchant marines[3]. Other states imported Dutch shipwrights to show them how to make the best ships[4]. In the case of France, Jean-Baptiste Colbert, the finance minister of King Louis XIV, even sent spies, three of them in 1669, 1670 and 1671, to watch shipbuilders in action at home in Holland and to bring back guidelines for French shipwrights. The trio included his own son, along with two others knowledgeable in shipbuilding. The minister gave precise directions about what they were to find out. The spies went to Holland, to England and one went to Italy. Each was to compare building methods with those in France[5]. Their extensive reports along with the sketches they supplied of Dutch shipbuilding were part of the fascination with Dutch success and another sign of the superiority of the work of Low Countries construction practices.

In the late fifteenth and first half of the sixteenth century Portuguese shipbuilding was the standard for quality in Europe. It was in that way in a similar position to the one the Dutch industry was to hold in the following century and a half. Portuguese sailors made their impressive long distances voyages in the products of domestic yards. Shipbuilders launched not just small vessels that could make their way along unknown coasts and also carry paying cargoes. They produced the larger cousins of those craft with similar rigs which in turn could serve effectively in trades to the Atlantic islands and on to Brazil. The most impressive of all the ships that came down the slipways along the Tagus and elsewhere in the world were the giants able to make the long voyage around the Cape of Good Hope and across the open ocean to India. Those vessels that came from yards in Lisbon and smaller ports up the coast to the north reached sizes and levels of efficiency not seen since the Roman Empire. Foreigners were astounded by the scale of those Portuguese behemoths. The variety and quality of Portuguese ships made them vessels to imitate and Portuguese shipbuilders furnished invaluable examples of how to approach the task of constructing the most impressive vessels of the day[6].

In both cases, first with the Portuguese and then with the Dutch, it was the ability to provide the latest and best technology that made them stand out and also made them the envy of other Europeans. For the Dutch certainly by 1600 it was also the ability to produce large numbers of ships and to do so quickly whereas for the Portuguese it was more the size of each of the massive sea-going giants rather than the number of vessels that ensured their place of prominence. In Portugal both royal shipyards and private enterprises participated in supplying effective vessels. In the Dutch Republic at least through much of the seventeenth century most of the many ships came from yards owned and operated by independent shipwrights. The difference in ownership seemed to make little difference in levels of skill. In Portugal the demands of politics

[3] DAVIS, 1962: 48-54. The English followed the practice of Spanish and then French privateers based at Dunkirk. BAETENS,1976: 50-65. The Dutch did retaliate. BRUIJN, 1979.

[4] For example DILLEN, 1974: vol. 3, n.º 40 (1633), n.º 1312 (1655), n.º 1313 (1655), n.º 1316 (1655), n.º 1369 (1668).

[5] COLBERT & CLÉMENT, 1864-1865: vol. 3, part 1, 132-133, 199-200, 211.

[6] For a discussion of the products of Portuguese shipyards, DOMINGUES, 2004: 221-299.

may have impinged more on what sorts of ships were built and where the work was done and possibly been a cause of problems on the route to India in the second half of the sixteenth century. Otherwise accomplishments were similar. In both cases their superior ships led to commercial success for shippers and traders in their countries and also to international trading empires. Of course the design and construction of ships was not the only factor creating those international networks of exchange and authority. For the fledgling Dutch Republic and for the struggling Portuguese kingdom having the ability to dominate the seas was a critical factor for commercial and political success, an example imitated by one state after another in later centuries.

The Portuguese ran into difficulties, technical in shipbuilding and politically in union with the Spanish crown, in the later sixteenth century just as Dutch commercial exchange was enjoying a sharp improvement. Despite the problems, the Portuguese were able to bounce back in the course of the seventeenth century and not only endured but also prospered as a centre of commerce and shipbuilding. The Dutch ran into difficulties in the eighteenth century, faced with a multitude of political threats and increasing commercial competition, but they endured, continued to enjoy the highest standard of living possibly on the planet into the nineteenth century while also remaining a major shipping and shipbuilding country. Not incidentally Portuguese fortunes took a turn for the better in the eighteenth century. There was a revival in commerce and so in the merchant marine along with improvement in the economy which was, as in previous centuries, connected to effective transport over the ocean.

There were similarities in the success of the two and in the role of shipbuilding in that success but not in the kind and type of ships they built or the methods that dominated their shipbuilding wharves. The Portuguese excelled in the construction of very large vessels for long distance travel. First it was carracks for voyages between parts of Europe especially Portugal and the Low Countries. Trade to the northern part of the continent grew as the newly expanding exchange with west Africa, a by-product of voyages of exploration, generated cargoes for sale in European ports. Second it was the giants for travel back and forth to India and parts of East Asia. At the same time shipwrights constructed smaller vessels with unique rigs for long reaches across the Atlantic. There was extensive fishing inshore and on the ocean which created demand for various boat types of different dimensions for local markets. The Dutch, on the other hand, built slow moving bulk carriers for short voyages within Europe. Costs were critical to success since the value for each unit of volume of those cargoes was much lower than for the goods in Portuguese holds. The Dutch compensated for the low unit profits by shipping large quantities of goods and not in large ships but in large numbers of ships. By the seventeenth century some Dutch captains were making extra-European voyages which placed new and more varied demands on the shipyards of the Low Countries. Despite the voyages to the East Indies and the New World it was intra-European bulk trades which continued to be the basis for prosperity and bulk carriers remained the principal products of the booming shipbuilding wharves. The Dutch had an extensive fishery as well, the most lucrative being in the North Sea. The fishers used specific types designed to catch specific species.

The locations of the two emerging states, one a kingdom the other a republic, dictated to a great extent the character of commerce. Portugal had a lengthy coast on the Atlantic Ocean. There were many inlets and a few mouths of rivers that produced likely locations for harbours and so for shipyards. Inland navigation was difficult since, other than the Tagus, river navigation was made difficult by the narrowness and the fall of the streams that came down from the hills in the central and eastern part of the kingdom. The location in southern Europe and jutting out into the Atlantic on the western fringe of Iberia made long distance trade logical. Equally logical was taking on the role of intermediary in exchange between northern Europe and Africa as well as a supplier of New World products to the Old. The differences in topography and geography between Portugal and the Dutch Republic were reflected in differences in commercial patterns and in ships built. Largely in the delta of the Rhine River, the Low Countries were a maze of rivers and streams with lakes spread around the landscape. Over time the residents enclosed swamps and lakes to create farmland. To that end they built canals for drainage but also avenues for travel. Transportation inland was largely by water. There were no hills or fast flowing streams to worry about. The North Sea offered access to the Atlantic Ocean and to the Baltic but in both cases with seaways that needed to be negotiated, a task that could prove difficult in contrary weather conditions. The seas and the Rhine made the Low Countries the logical centre for the distribution of goods from eastern Europe and from the south to seaports in the north as well as to towns along the extensive river system in western Germany. Dutch shipbuilders and merchants in the course of the seventeenth century also made the Low Countries the entrepot for goods from Asia and the New World, using existing networks of distribution and getting goods from distant ports by expanding the scope of their shipping to all parts of the world. Vessels had to be of shallow draught to reach many Dutch ports, a problem that rarely vexed Portuguese builders. The ability to reach many different types of ports was also a requirement of Dutch ships that was not generally one in Portugal. It was often advantageous to move the colonial goods that were a central feature of Portuguese trade quickly so speed was more important than in the Netherlands where grain and fish and salt could make their way at a slow pace to their destinations.

Circumstances, economic, technological and geographical, made Portuguese and Dutch commerce different and so made the demands placed on the designers and builders of ships different in significant ways. The expectation then is that there would have been little relationship between Dutch and Portuguese shipbuilding. Any connection between the two industries and enterprises is not obvious. There is rarely any mention of the two together. However, there were two facets of ship construction which showed ties between the building of ships in the two states. First, there was a practical connection. The Dutch relied on Portuguese and Iberian forms in general to guide them in developing a syncretic building method and then in moving on to a full imitation of southern practice. The adoption of the way Portuguese shipbuilders designed their vessels allowed the Dutch to produce the types and the range of vessels that brought them so much success. Second, there was a theoretical connection. When native writers in the late seventeenth century came to describe Dutch construction practices and, in the process, to give some theoretical basis for those practices, in general and in one specific case it was inspiration from Portugal which offered guidance.

Portuguese shipbuilders were early adopters of what emerged in the Middle Ages as the Mediterranean/Iberian/Atlantic method of construction. There were predecessors and some remnants through the late medieval centuries of more northerly designs that came from Lusitanian shipyards. Northern Europeans from Scandinavia and later from England and the Low Countries visited the Portuguese coast starting in the ninth century if not before, exposing local builders to the common design features of ships in the tradition of the German rowing barge[7]. The barks built and used along the Iberian Atlantic coast were smaller ships and may well, like keels in England and France, have descended from the sea-going cargo vessels of Vikings. Little is known about the type of vessel built in Iberia but the vessels in England and France, illustrated on town seals, show overlapping planking of the hull and a single square sail on a single mast stepped in about the middle of the ship. Barks could be serviceable open fishing vessels as well as coastal traders. Portuguese builders also generated by the fourteenth century a modified sea-going ship derived from a Mediterranean fishing boat. Caravels proved highly useful along the African coast and have enjoyed a great deal of notoriety among historians for their role in exploration in the fourteenth and fifteenth centuries.

The most impressive accomplishment and the one with the greatest impact, both in the short and long term was the Portuguese version of the carrack. It was a full-rigged ship, the exact dating of the emergence of the type with a combination of square and lateen sails is not known though probably it occurred in the late fourteenth century in or around Portugal. Hulls by that time were built frame-first. That form of construction was in common use in southern Europe by the year 1000. The method evolved from Roman practice of building hull-first with the new approach appearing in the first half of the Middle Ages and probably in the eastern Mediterranean. Portuguese shipbuilders had absorbed and embraced the way to build hulls and they quickly took up the combination rig with three masts, the one at the stern carrying a triangular lateen sail, the one in the middle carrying a large square sail and the one at the bow rigged with a small square

[7] For a concise discussion of medieval trade relations in general see CHILDS, 2013.

sail to offer some balance to the sail at the stern as well as to aid in steering. The rig relied heavily on the single large mainsail to power the ship through the water with the other smaller sails acting as supplements and aids in shiphandling. Once the new design emerged, builders in Portugal went to work, learning to exploit the potential of the novel marriage of different design features. By the end of the fifteenth century they built carracks capable of carrying sizeable cargoes on regular voyages to northern Europe and across newly-discovered all-sea routes to the New World and to India.

The Portuguese vessel types and forms of construction which made the greatest impression at the time and even now were those big carracks, the biggest being used on the India route. While archaeology has produced details of how builders formed the hull, it is contemporary images of the ships that show the rig and how sailors used the sails. The images, along with vessels excavated, also indicate the relative size of the most impressive products of Portuguese shipbuilding yards. The frames which gave shape and strength to the hull were built up from various pieces and typically linked together with lapped dovetail joints. The way of creating the frames was not really distinctive and the practice is known in other contemporary shipbuilding traditions. The shipwrights laid the keel first and then put up the frames, the principal ones followed by the rest, and then they added the abutting planks to form the watertight hull. Additional planking internally was an option to improve and enhance the integrity of the vessel. The ships ran in length to 25, 35 and even 40 metres, sizes not seen since Antiquity so the method did ensure the ability to build large ships[8]. One reason that was possible was the use of heavy framing. The number of frames per unit of length was, however, lower than was typical of Dutch ships. Indeed, one of the principal differences between Portuguese and Dutch practices was the relatively higher number of frames and lighter frames in vessels built in the Low Countries[9].

As more wrecks, both Dutch and Portuguese, come to light, it will be possible to identify even more features, at least of hull construction, that separated the two shipbuilding traditions. The history of ship design and of nautical technology in general was until the middle of the twentieth century based on written and pictorial evidence. The mentions or descriptions of ships and navigation methods presented some problems since they were imprecise or cast in language unfamiliar to a modern reader. The problems with interpretation increased the further back in the past any research went. With illustrations ships were often incidental to what artists set out to depict. The medium often dictated distortions in portraying vessels, most obvious with the town seals that provide valuable information about high and late medieval ships in northern Europe because

[8] On construction methods see the well-illustrated archeological report on a carrack returning from India and wrecked opposite Lisbon in 1606 by ALVES *et al*., 1998: 194-210. For a full and careful analysis of the construction of the ship see CASTRO, 2005: 47-58, 105-88. MAARLEVELD, 1992: 158-160.
[9] MAARLEVELD, 2013: 353-56.

the seals had to be round. Whether the ships on those seals were as round as they appear is uncertain. Manuscript illumination might also dictate a certain shape and size to the depiction of a ship. When artists added ships as decoration on maps, something they did more and more frequently in the sixteenth century, they gradually succumbed to standardization, even copying the same type and form of ship whether it accurately reflected current conditions or not[10]. There was the enduring problem that artists typically were not familiar with ships or sailing practices. Only in the fifteenth century when the first texts describing shipbuilding began to appear did sketches of ships and their parts come from people with experience of how to construct vessels[11]. It was in the seventeenth century that sailors turned to drawing and painting ships. From then on works of art became more precise and more reliable. The development of conventions for scientific illustration added to the quality, in terms of transmitting an understanding of the technology involved, of pictures of ships. The limited scope and reliability of sources changed dramatically with the development of SCUBA gear in the mid twentieth century and its use in exploring the sea floor. Relatively quickly and then with greater frequency archaeologists took advantage of the ability to examine shipwrecks. The early successes, especially in the Mediterranean, generated increased interest in nautical archaeology and the perfecting of other methods to study ship remains and to preserve them. In the Netherlands in particular the completion of the enclosing dike which made the Zuider Zee into an inland lake, the Ijsselmeer, and the subsequent draining of portions of the lake to create large polders created a boon for archaeologists. As farmers went to work on their newly dry fields they found the remnants of vessels lost in some 650 years that the land had been under water. The study of those more than 400 wrecks has generated a wealth of information about the evolution of Dutch shipbuilding and with an accuracy never possible before[12].

The wealth of new information, while complementing and clarifying what is known from other sources, gives a much more complete and accurate picture of the development of shipbuilding and nautical technology in medieval and early modern Europe. As archaeological investigations continue and, even more important, as the results of the careful analysis that is now typical of the field are made available to readers, a much more precise picture of both Portuguese and Dutch maritime technology will emerge. Much more is now known about the giant carracks that came from Portuguese shipyards. It seems that they did not have all the same design features as other types of vessels produced in the kingdom. Their features may not even have been typical. Knowledge of the details of construction, coming from archaeology and illustrations, strongly suggests

[10] UNGER, 2010: 152-69.
[11] See for example MICHAEL *et al.*, 2009: vol. 1.
[12] On the early development of work in the polders and the expectations for the future of those involved see HEIDE, 1974: 363-456; HOLK, 2003: 296.

that they were not representative of Portuguese shipbuilding. From written sources, though, it seems clear that it was the very large vessels which impressed contemporaries, set Portuguese ships apart and which served as the basis for the world-spanning commercial empire of the sixteenth century[13]. Their now-documented technical features indicated the potential, in both rig and hull design, for Portuguese shipbuilding. It was the vessels which opened new avenues of intercontinental commerce and shifted the geopolitical balance which impressed contemporaries. It was the building and use of those carracks which others recognized as a pattern to follow.

In the Low Countries what the Portuguese did so impressed the ruler that he turned to Lusitanian shipwrights to introduce his people and his lands to Mediterranean/Iberian ship design. Duke Philip the Good of Burgundy, ruler of much of the Low Countries in 1439 brought Portuguese craftsmen to his emerging capital at Brussels to build a ship. The vessel, which was lost to pirates on a trip to the Mediterranean seven years later, was built all but certainly in the Iberian way with heavy frames set up first. That was not the only case of people in the Netherlands seeking out examples of the products of southern shipbuilding. Records from 1457, 1468 and 1477 show governments acquiring ships from Iberia for naval use. Though by 1460 vessels of frame-first construction in imitation of Portuguese practice were coming from Low Countries yards, it is now clear from archeological evidence that Dutch builders did not simply copy what was done in the South but that they modified those methods in light of both their own knowledge and traditions as well as the commercial and geographical circumstances[14].

Traditional Dutch shipbuilding followed the norm of medieval northern Europe. Hulls were clinker-built. The overlapping external planks supplied structural integrity and watertightness. Builders put up the hull first. They added the frames and other internal strengthening after the hull was complete or at least nearly complete. There was a type with Celtic roots and features of Nordic practice which evolved in the course of the twelfth and early thirteenth century to become the major bulk carrier in the North and Baltic Seas. The cog is usually associated with the ports on the north German coast which belonged to the Hanseatic League. Archaeological as well as documentary evidence indicates that Low Countries builders produced them as well with something close to half of the known cog wrecks dating from around 1150 to the early fifteenth century found in the Low Countries[15]. While there has been some recent discussion about the exact character of the cog and how the name was applied and though there were certainly variations in the details of construction, over time and from one part of

[13] An example was the *Madre de Dios*, captured by English privateers in 1592 on a return trip from India. Contemporaries were more interested in the valuable cargo than what was the largest ship ever seen in England at more than 53 metres in length. She remained at anchor at Dartmouth for some time and did draw visitors (BOVILL, 1968: 138-45; KINGSFORD, 1910: 91).

[14] BEYLEN, 1970: 7-8; UNGER, 1978: 32-33.

[15] HOCKER & DALY, 2016: 187.

northern Europe to another there were certain features that usually marked vessels that can be called cogs or cog-like. By the fourteenth century the type was certainly a flat--bottomed cargo ship[16]. There were variations in construction, variations which appear to have increased over time, possibly under influence from southern Europe. The sides were clinker-built and the bottom had flush planking. The cog was built shell-first with strength coming from external planks and not from the frames which wrights added later to offer reinforcement and stability. The overlapping planks were typically held in place with iron nails, in many cases though not always bent over twice. Not all vessels with lapstrake construction had consistent use of nails. Some had their planks fixed to each other with roves and rivets or treenails or even with a combination of the two types of fastening though the last may have been rare. Treenails may have been typically the preferred solution for planks that would remain underwater since after launch the wooden pegs would have expanded and so created a tighter fit[17]. The keel was rather a bottom plank, typically light and not much thicker or heavier than the other planks that formed the flat bottom. It was more a strake holding both sides together than a spine for the ship. That gave the cog a relatively shallow draught which was an important feature in a region with shallow streams and lakes. Still it was that central plank in combination with the straight posts at stem and stern, attached to the keel with angled timbers called hooks, that formed the backbone of the ship[18].

To hold the abutting bottom planks in place during construction, that is before putting on the sides and setting up the frames, builders placed small cleats on the outside and held those in place with treenails. Once work was done and the hull was sound, they took away the small pieces of wood stretched perpendicularly across the seams and then filled the holes left when they extracted the treenails with small nail-like pieces of wood called *spijkerpennen*. That was not true of all cogs though few of the wrecks excavated so far lack the remnants of the use of cleats to keep the bottom planks in place during construction. At the turn of the sides where the flat-bottom flush planking changed to curved overlapping planking at least in one case from around the 1330s there are more *spijkerpennen* than on the bottom, suggesting that extra reinforcement was needed to take the strain from the curving of the planks[19]. A wreck found in 1962 in Bremen harbour and dated to about 1380 is the most complete surviving example of a cog and one of the largest studied by archaeologists to date. As with all wrecks, the rigging is lost so determining the size of the sail and how it was handled is difficult. Tempted by the challenge, some shipwrights at the end of the twentieth century took on the task of

[16] Some ten wrecks from the polders in the Ijsselmeer are cogs or have many features of cogs. ADAMS & RÖNNBY, 2002: 176; JAHNKE & ENGLERT, 2016; JAHNKE, 2011; HOCKER, 2004; ELLMERS, 2010.
[17] HOLK, 2003: 288-304.
[18] MOORTEL *et al*., 1991: 15, 27, 36; VERMEERSCH & HANECA, 2015: 127.
[19] MAARLEVELD *et al*., 1994: 19-24; ADAMS & RÖNNBY, 2002: 178; MOORTEL, 1991: 63-65, 86-88; VERMEERSCH & HANECA, 2015: 114-118; VERMEERSCH *et al.*, 2015: 331-332.

recreating the Bremen cog. Three full-scale replicas have sailed and with some success. The rig varies among them though handling the sail and the ship proved difficult in all cases[20].

Evidence from cog finds shows that through the Late Middle Ages Dutch building methods were similar to those in the rest of northern Europe and especially to what was done in north Germany. There was a deep divide between Mediterranean methods and northern ones, major differences in the design of hulls and rigging and in the ways shipbuilders created those designs. In the fifteenth century the injection of Portuguese practices into the Low Countries led to incomplete imitation and the emergence of a unique kind of shipbuilding which, while adhering to established traditions, created a unique and, for the better part of two centuries, highly successful approach to construction of a sea-going sailing ship.

The Dutch hybrid technique is another indication that pure systems just like pure and consistent ship types exist largely in the minds of historians. Builders developed their own approaches based on what they knew and what proved most effective. Dutch shipwrights evolved a way to take advantage of the features of Mediterranean/Iberian//Atlantic construction they learned from Portuguese examples while also employing their own established techniques[21]. A few illustrations and sparse descriptions from the late seventeenth century are the best sources for what was by then an old, outmoded and disappearing approach to the task. It recalled the ways of building a cog and the ways of building a carrack. First, as in both north and south, builders laid down the keel. They then added the garboard and bottom strakes, the progress being similar to what they did with cogs. As they built out they produced a flat bottom or something close to a flat bottom. To hold those bottom planks in place they used small cleats on the outside. The angle between the bottom and the side planks would be sharp, giving a box-like cross section though that did not come as a logical product of the method of building but rather as a matter of choice by shipwrights to improve carrying capacity. The next step was to put the frames in place though exactly at which point builders did that is not certain. Almost undoubtedly they placed the frames on the keel before the sides were completed but how much before may have varied over time and from builder to builder. Certainly by the late seventeenth century Dutch builders had adopted Portuguese practice and the frames came after the bottom and before the sides.

In a series of sixteen prints showing the life of a ship from beginning to the breakers yard dating to around 1700 the Alkmaar artist Siewert van der Meulen described the installation of the bottom strakes before including the frames and sides of the ship[22]. The Swedish writer Åke Rålamb, in his 1691 book on shipbuilding, offered a sketch of

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[20] HOFFMANN & HOFFMANN, 2009.
[21] MAARLEVELD, 1994.
[22] GROOT & VORSTMAN, 1980: 138-39.

work in a shipyard giving two approaches, a standard one consistent with Portuguese practice and, off in a corner, a way the Dutch built ships. He said it was a *fluit*, the very successful type that served to carry bulk cargoes, being built with small cleats which he called *klampar*[23]. One of the spies Louis XIV's minister, Jean-Baptiste Colbert, sent to the Republic to find out about Dutch building methods was Nicolas Arnoul, the son of the Marseilles Intendent des Galères and the future administrator of the naval shipyard in that port. His time there combined with an earlier trip to Italy to examine shipbuilding practice guaranteed he had an experienced eye. His report along with a sketch that he supplied to his superiors in Versailles confirms what turns up in the Swedish and Dutch illustrations, that the Dutch, unlike the French and English and Portuguese for that matter, put bottom planks up first and then moved on to the frames and the rest of the hull planking[24]. Construction of a replica of a seventeenth century Dutch Eastindiaman at the Bataviawerf in Lelystad where efforts were made to recreate original methods, within limitations, also tends to confirm that the Dutch built ships, or at least their cargo ships, differently from others in Europe. The same can be said for a ship excavated in the Noordoostpolder between 1957 and 1961 and conserved at what was the museum of the archaeological service at Ketelhaven[25].

There were some advantages to the hybrid approach which borrowed from but did not slavishly imitate Portuguese practice. The frames did not need to be built up with great care in advance. They did not need to be as heavy as with Portuguese construction. The Dutch apparently did not use lapped dovetail construction in frames but by the end of the sixteenth century the Portuguese had given up that extra work anyway. The shape of the principal frames did not have to be as strictly controlled perhaps in the Netherlands as with methods of building which predominated in Portugal and elsewhere in southern and western Europe[26]. Dutch builders had considerably more flexibility in the kind and shape of wood they used in building the frames. They could work on hull planking and frames at the same time and were not typically delayed waiting for heavy frames to be finished and fitted nor delayed by waiting for just the right piece of wood. It could be that the Dutch way meant that they could build ships more quickly[27]. Whether or not the method was the reason, it was certainly true that the Dutch were able to build ships faster and more cheaply than other Europeans. There is evidence that sailing ships in the Late Middle Ages through to the nineteenth century cost more to build for each unit of carrying capacity as they got bigger[28]. There is every reason to believe that was true of the carracks the Portuguese sent to Asia. The risk of loss may have been greater

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[23] RÅLAMB, 1691: 34-44.
[24] HASSLÖF, 1972; UNGER, 1985.
[25] Wreck E81NOP.
[26] SLEESWYK & SLEESWYK, 1998: 7-12.
[27] MAARLEVELD, 1992: 158, 165-69.
[28] SLEESWYK, 2003.

with larger ships and certainly the stories of Portuguese shipwrecks in trade to India from 1550 to 1650 would tend to support that assumption[29]. With larger ships the sheer size and complexity of the vessels increased the likelihood that something would go wrong. Dutch shippers avoided going to the building and using of very large ships in part, presumably, to control costs and also in part because the middle-range ships they deployed on intra-European voyages could be built more quickly. Equally important the slower, smaller ships were adequate for delivering the bulk goods which they carried. With vessels in an intermediate range Dutch shipwrights did not face the problems presented to Portuguese builders who had to make stronger ships with heavier planking for their long distance voyages when they were fully loaded or, as in many cases, more than fully loaded.

The archaeological and iconographic evidence indicates that the Dutch system of construction which emerged in the sixteenth century was unique. The way of building ships depended on well-established traditional northern practices and also on the knowledge gained from Portuguese imports of ships and of shipwrights. It also depended on how Low Countries builders adapted those foreign practices to what they knew and what they had done for centuries. It depended as well on the character of the trades Dutch merchants and shippers were involved in. Acquiring knowledge of alternate methods, adapting them, integrating them with existing practice creating some syncretic way of working and then finally to abandon the compromise and to accept fully the imported system proved to be a slow process. Over time Dutch building became ever more like Portuguese and the two increasingly fit into a more universal European and even global way of building a sea-going sailing ship.

Theory and practice merged. Dutch builders did not have need of a theoretical articulation of what they did. Because their method was a hybrid, describing it would have proven, and indeed did prove, difficult. In other parts of Europe, especially in the Mediterranean and notably in Portugal, there were theoreticians who wrote about how shipbuilders should think about what they were doing[30]. Importing ideas from southern Europe in maritime matters had a proven pedigree in the Low Countries. There was a well-established tradition of Portuguese influence on navigational thinking and practice. As pioneers in celestial navigation, forced on them by long north-south voyages out of sight of land and voyages to the Azores which were islands in the open sea, the Portuguese had a deep influence on practices throughout Europe. Series of sailing instruction, roteiros, were known and a model for books produced in the Low Countries like the so-called *leeskaart* of Jan Severszoon, the first of its type produced in Amsterdam in 1532, and the subsequent 1558 *Onderwijsinge van der zee* by Cornelis Anthonisz. That was the beginning of a tradition of the adoption of Iberian practices among

[29] BRITO & BOXER, 1959: 24-27.
[30] MAARLEVELD, 1994: 154, 159.

northern sailors in the Low Countries and in, for example, England as well[31]. As Dutch cartographers started to produce maps in the sixteenth century, they borrowed from Portuguese practices, most obviously in the decoration of the seas and the lands they depicted. This may have come through direct knowledge of what went on in Iberia from the personal experience of Dutchmen working there or through seeing the maps that came from Iberia or through the intermediary of practices in France, specifically in Dieppe where in the mid sixteenth century a small group of men made impressive maps very much in the Portuguese style[32]. The Low Countries map maker Gerard Kramer, better known by his Latinized name of Mercator, developed a projection for maps which created loxodromes, lines which intersect all meridians at the same angle and so show the true course of a ship. He first produced that projection in 1541, just four years after the Portuguese mathematician Pedro Nunes had discussed how to carry out the calculations to get Mercator's result[33].

Writers in the Dutch Republic, when they did turn to the theory of shipbuilding in the late seventeenth century, relied on Portuguese work as well. A practice emerged in the fifteenth century in Italy of writing about shipbuilding. The few books produced were highly descriptive and probably not very useful as practical manuals for workers on wharves. Once the practice started and a language developed for writing about shipbuilding, works appeared in Spanish, Portuguese, French and Dutch which were increasingly accurate, precise and of value in developing the skills of shipbuilders[34]. In the Netherlands the progression was from a work by a wealthy amateur observer to a practitioner with extensive experience building ships. Nicolas Witsen came from a well-off Amsterdam family and the book he published in 1671 incorporated information from what he learned from men on wharves. Cornelis van Yk, whose book came out in 1697, had spent a lifetime as a professional shipbuilder. Both books indicate that there was considerable variety in the kinds of ships that came from Dutch yards. Their works, largely empirical, lacked signs of the systematic approach that was becoming common in works by writers coming from an Iberian or even an English shipbuilding tradition. Witsen's book which, in its first edition, was largely a catalogue of practices, indicates that shipbuilding in the Netherlands used a hybrid system. He did feel the obligation to offer some theoretical framework and for that he turned to a book, probably in the hands of the Dutch humanist Isaak Vossius at the time, written by the Portuguese man of letters and character of a number of careers, Fernando Oliveira. His *Ars Nautica*, written in the 1550s, had an unfinished but still extensive middle section which dealt with shipbuilding, a topic he would treat more completely in his *Liuro da*

31 KEUNING, 1952: 57-59; WARD, 2009: 147-150.
32 UNGER, 2010: 84, 118-124, 144-146.
33 ASH, 2007: 513-14, 520-22; KYEWSKI, 1962: 116-17; UNGER, 2011.
34 BONDIOLI, 2009: 261-66, 271-80; UNGER, 2013: 187-91.

Fabrica das Naos of 1580[35]. Relying on the Portuguese work, Witsen thought he was describing the way ships were built in the distant past, that is in the 1520s. He used Oliveira's drawings of the progress of ship construction verbatim and then, dropping the nod to theory, moved on to his description of contemporary practices. It would seem that Witsen was aware that Dutch builders did not follow the Portuguese pattern and that he knew Dutch hull design was different. At the same time his use of Oliveira suggests that he, and others, thought there were different notable and effective ways to think about sailing ships and about how to build them. It also suggests that he revered Portuguese practice as superior, at least as it was back 150 years before he was writing.

Dutch designs and construction procedures changed in the seventeenth and even more in the eighteenth century. Rembrandt's 1633 painting of a shipbuilder handing his wife a drawing of the principal frame of a ship, suggesting that the sketch was critical to the execution of his trade, meant that builders were already thinking like their counterparts in Iberia. Van Yk, in describing construction, talks about putting up the frames first in contrast to Witsen who showed the older system[36]. As Dutch trading connections spread around the world in the seventeenth century, shippers needed vessels more like those in use in Portugal. The eighteenth-century East Indiamen of the Dutch East India Company were like the heavily-built, large, defensible ships of all other European states trading to the Far East[37]. Dutch vessels used within Europe increasingly shared characteristics of the ships and boats of other parts of the continent. The decision to bring English shipwrights to the Amsterdam Admiralty wharf to train Dutch builders in the latest techniques in 1727, as a way to meet criticism of the poor quality of Dutch warships compared to French and British ones, was just another sign of falling in line with general European methods[38].

Archaeology will certainly over time add more knowledge about how Portuguese and Dutch shipwrights built their ships. Speculation about the shape and extent of the effects of one on the other depends heavily on archaeological finds. Relying only on contemporary descriptions and surviving images would not have revealed the extent and character of potential influence that most likely existed. It could well be that the flow of technical knowledge and practices was not just in one direction. It may be that cross-fertilization travelled south as well as north. Working at Red Bay in Labrador, Robert Grenier and his team of underwater archaeologists from Parks Canada excavated sixteenth-century Basque whaling ships. Having learned that Dutch builders made small holes in hull planks to hold cleats in place and then, when done, filled the small holes

[35] VOGEL, 1911. The book is now in the Leiden University Library. I am indebted to Richard Barker for his pointing out my earlier oversight in describing the book. On the life and works of Oliveira see DOMINGUES, 2008.

[36] HOVING, 2012: 8-11.

[37] MAARLEVELD, 2013: 350.

[38] BRUIJN, 1972. The experiment, despite some successes, failed in its purpose, and criticism of Dutch warships continued.

with *spijkerpennen*, he looked for signs of similar remnants on the hull of the large ship he was then diving on. He found evidence of something very similar to the use of *spijkerpennen*. The plugs were all at strategic points, which indicates that some temporary pieces of wood served to outline the shape of parts of the hull during construction[39]. The conception of the building process and its progression were different on Basque wharves from those on Dutch ones. Filling small holes with dowels does not show that Iberian builders used temporary cleats in constructions nor that they picked up practices from the Low Countries. The presence of plugs may show nothing more than a practical way for all builders to deal with nail holes that were temporary. On the other hand the consistency of practice in Iberia and the Netherlands strongly suggests that shipbuilders in those two parts of Europe were familiar with what their counterparts were doing and that, even if slowly, were willing to exploit what they learned from others. There is promise to learn much more about how contact among shipbuilders, directly through migration and indirectly through seeing the products of other practitioners, affected practices. Experimental archaeology, the construction of replicas in all sizes of historic vessels based on what is learned from digs and from the classic sources of texts and images, together will lead to a better understanding of how and why and to what degree technology got transferred and how Europeans came to build the very effective ships that they put together in the early modern era.

SOURCES

ADAMS, Jonathan; RÖNNBY Johan (2002) — *Kuggmaren 1: The First Cog Find in the Stockholm Archipelago, Sweden*. «International Journal of Nautical Archaeology», vol. 31, n.º 2, p. 172-181.

ALVES, Francisco *et al*. (1998) — *Archaeology of a Shipwreck*. In MARTINS, António Alves, *ed*. — *Nossa Senhora dos Mártires: The Last Voyage*. Lisbon: Editorial Verbo, p. 183-215.

ASH, Eric H. (2007) — *Navigation Techniques and Practice in the Renaissance*. In WOODWARD, D. — *The History of Cartography: Cartography in the Renaissance*. Chicago: University of Chicago Press, p. 509-527.

BAETENS, R. (1976) — *The Organization and Effects of Flemish Privateering in the Seventeenth Century*. In BAETENS, R. *et al*. — *Acta Historiae Neerlandica IX: Studies on the History of the Netherlands*. Leiden: [s.n.], p. 45-75.

BARBOUR, Violet (1930) — *Dutch and English Merchant Shipping in the Seventeenth Century*. «Economic History Review», n.º 2, p. 261-290.

BEYLEN, Jan van (1970) — *Schepen Van De Nederlanden*. Amsterdam: P. N. Van Kampen & Zoon N. V.

BONDIOLI, Mauro (2009) — *Early Shipbuilding Records and the Book of Michael of Rhodes*. In O. LONG, Pamela; MCGEE, David; STAHL, Alan M.; ROSSI, Franco — *The Book of Michael of Rhodes: A Fifteenth-Century Maritime Manuscript*. Cambridge, Mass.: MIT Press, p. 243-280.

BOVILL, E. W. (1968) — *The Madre de Dios*. «The Mariner's Mirror», vol. 54, n.º 2, p. 129-152.

BRITO, Bernardo Gomes de; BOXER, C. R. (1959) — *The Tragic History of the Sea, 1589-1622; Narratives of the Shipwrecks of the Portuguese East Indiamen São Thomé (1589), Santo Alberto (1593), São João*

[39] LOEWEN, 2007: vol. 3, 79, 82.

Baptista (1622), and the Journeys of the Survivors in South East Africa. Cambridge: Hakluyt Society at the University Press.

BRUIJN, J. R. (1972) — *Engelse Scheepsbouwers Op De Amsterdamse Admiraliteitswerf in De Achttiende Eeuw: Enige Aspecten*. «Mededelingen van de Nederlandse Vereniging voor Zeegeschiedenis», n.º 25, p. 18-24.

_____ (1979) — *Dutch Privateering During the Second and Third Anglo-Dutch Wars. In The Low Countries History Yearbook 1978: Acta Historicae Neerlandicae.* [S.l.]: Springer, p. 79-93.

CASTRO, Filipe (2005) — *The Pepper Wreck: A Portuguese Indiaman at the Mouth of the Tagus River*. Texas: Texas A&M University Press.

CHILDS, Wendy R. (2013) — *Trade and Shipping in the Medieval West: Portugal, Castile and England: A Series of Lectures in Memoriam of Professor Armindo de Sousa, Given in the University of Porto, November 2009. Textes et Études du Moyen Âge*. Porto: Fédération internationale des instituts d'études médiévales.

COLBERT, Jean Baptiste; CLÉMENT, Pierre (1864-1865) — *Lettres, Instructions Et Mémoires De Colbert*. Paris: Imprimerie impériale, vol. 3, part. 1.

DAVIS, Ralph (1962) — *The Rise of the English Shipping Industry in the Seventeenth and Eighteenth Centuries.* London; New York: Macmillan; St. Martin's Press.

DE VRIES, Jan; WOUDE, A. M. van der (1997) — *The First Modern Economy: Success, Failure, and Perseverance of the Dutch Economy, 1500-1815*. Cambridge; New York: Cambridge University Press.

DILLEN, J. G. van (1974) — *Bronnen Tot De Geschiedenis Van Het Bedrijfsleven En Het Gildewezen Van Amsterdam*. 's-Gravenhage: Nijhoff. 3 vols.

DOMINGUES, Francisco Contente (2004) — *Os Navios do Mar Oceano. Teoria e Empiria na Arquitectura Naval Portuguesa dos Séculos XVI e XVII*. Lisboa: Centro de História da Universidade de Lisboa.

_____ (2008) — *Experiência e Conhecimento na Construção Naval Portuguesa do Século XVI. Os Tratados de Fernando Oliveira*. In *Navios E Viagens: A Experiência Portuguesa dos Séculos XV a XVIII*. Lisbon: Tribuna da História, p. 49-83.

ELLMERS, Detlev (2010) — *Koggen Kontrovers*. «Hansische Geschichtsblätter», n.º 128, p. 113-40.

GROOT, Irene de; VORSTMAN, Robert (1980) — *Sailing Ships. Prints by the Dutch Masters from the Sixteenth to the Nineteenth Century*. New York: Uitgeverij G. Schwartz; Viking Press.

HASSLÖF, Olof (1972) — *Main Principles in the Technology of Ship-Building.* In HENNINGSEN, Henning, *et al. — Ships and Shipyards, Sailors and Fishermen; Introduction to Maritime Ethnology*. Copenhagen: Copenhagen University Press, p. 27-72.

HEIDE, G. D. van der (1974) — *Scheepsarcheologie Scheepsopgavingen in Nederland En Elders in De Wereld*. Naarden: A. G. J. Strengholt's Boeken.

HOCKER, F. M. (2004) — *Bottom-Based Shipbuilding in Northwestern Europe*. In HOCKER, F. M.; WARD, Cheryl A. — *The Philosophy of Shipbuilding: Conceptual Approaches to the Study of Wooden Ships*. College Station: Texas A&M University Press, p. 65-93.

HOCKER, F.; DALY, Aoife (2016) — *Early Cogs, Jutland Boat builders and the Connection between East and West before AD 1250*. In BLUE, Lucy Katherine; HOCKER, F. M.; ENGLERT, Anton — *Connected by the Sea: Proceedings of the Tenth International Symposium on Boat and Ship Archaeology, Roskilde 2003*. Oxford: Oxbow Books, p. 187-94.

HOFFMANN, Gabriele; HOFFMANN, Per (2009) — *Sailing the Bremen Cog*. «International Journal of Nautical Archaeology», vol. 38, n.º 2, p. 281-96.

HOLK, André van (2003) — *Clenched Lap-Strake Boat Finds from the Netherlands between 1200 and 1600*. In BELTRAME, Carlo — *Boats, Ships and Shipyards: Proceedings of the Ninth International Symposium on Boat and Ship Archaeology, Venice 2000*. Oxford: Oxbow Books, 296-305.

HOVING, A. J. (2012) — *Nicolaes Witsen and Shipbuilding in the Dutch Golden Age*. College Station: Texas A&M University Press.

JAHNKE, Carsten (2011) — *Koggen Und Kein Ende Anmerkungen Zu Den Thesen Von Reinhard Paulsen Und Detlev Ellmers*. «Zeitschrift für Lübeckische Geschichte», n.º 91, p. 305-20.

JAHNKE, Carsten; ENGLERT, Anton (2016) — *Historical Research on Merchant Sea-faring in Danish Waters and in the Western Baltic Sea 1000-1250*. In ENGLERT, Anton — *Large Cargo Ships in Danish Waters 1000-1250. Evidence of Specialised Merchant Seafaring Prior to the Hanseatic Period*. Roskilde: The Viking Ship Museum, p. 30-75.

KEUNING, Johannes (1952) — *XVIth Century Cartography in the Netherlands*. «Imago Mundi», n.º 9, p. 35-63.

KINGSFORD, C. Lethbridge (1910) — *The Taking of the Madre de Dios, Anno 1592*. In LAUGHTON, John Knox; Navy Records Society, *eds*. — *The Naval Miscellany II*. London: Navy Records Society, vol. 40, p. 85-121.

KYEWSKI, Bruno (1962) — *Über Die Mercatorprojektion*. In STADTARCHIV DUISBURG — *Duisburger Forschungen Schriftreihe für Geschichte und Heimatkunde Duisburgs*. Duisburg-Ruhrort: Verlag für Kultur Werner Renckhoff KG, 115-30.

LOEWEN, Brad (2007) — *The Hull: Of Ship Design and Carpentry*. In BERNIER, Marc A.; GRENIER, Robert; STEVENS, Willis — *The Underwater Archaeology of Red Bay: Basque Shipbuilding and Whaling in the 16th Century*. Ottawa: Parks Canada, vol. III, 25-148.

LONG, Pamela O.; MCGEE, David; STAHL, Alan M.; ROSSI, Franco (2009) — *The Book of Michael of Rhodes: A Fifteenth-Century Maritime Manuscript*. Cambridge, Mass.: MIT Press, 3 vols.

MAARLEVELD, Thijs J. (1992) — *Archaeology and Early Modern Merchant Ships, Building Sequence and Consequences. An Introductory Review*. In CARMIGGELT, Arnold — *Rotterdam Papers VII: A Contribution to Medieval Archaeology. Teksten Van Lezingen Gehouden Tijdens Het Symposium 'Handel, Handelsplaatsen En Handelswaar Vanaf De Vroege Middeleeuwen in De Lage Landen' Te Rotterdam, Van 2 T/M 3 November 1990*. Rotterdam: Cooerdinatie Commissie van Advies Inzake Archeologisch Onderzoek Binnen het Ressort Rotterdam, 155-173.

_____ (1994) — *Double Dutch Solutions in Flush-Planked Shipbuilding*. In WESTER-DAHL, Christer — *Crossroads in Ancient Shipbuilding: Proceedings of the Sixth International Symposium on Boat and Ship Archaeology, Roskilde, 1991, ISBSA 6*. Oxford: Oxbow Books, 153-163.

_____ (2013) — *Early Modern Merchant Ships, Nicolaes Witsen and a Dutch-Flush Index*. «International Journal of Nautical Archaeology», vol. 42, n.º 2, p. 348-57.

MAARLEVELD, Thijs J.; GOUDSWAARD, B.; OOSTING., R. (1994) — *New Data on Early Modern Dutch--Flush Shipbuilding: Scheurrak T24 and Inschot/Zuidoostrak*. «International Journal of Nautical Archaeology», vol. 23, n.º 1, p. 13-25.

MOORTEL, Aleydis van de *et al*. (1991) — *A Cog-Like Vessel from the Netherlands*. Lelystad: Rijkswaterstaat Directie Flevoland.

PRAK, Maarten Roy; WEBB, Diane (2005) — *The Dutch Republic in the Seventeenth Century: The Golden Age*. Cambridge; New York: Cambridge University Press.

RÅLAMB, A. (1691) — *Skepps Byggerij Eller Adelig Öfnings*. [n.s.: n.p.].

SLEESWYK, André Wegener (2003) — *Building Costs and Carrying Capacity of European Merchant Ships, 1400-1800*. «Tijdschrift voor zeegeschiedenis», vol. 22, n.º 2, p. 137-146.

SLEESWYK, André Wegener; SLEESWYK, M. Wegener (1998) — *Joseph Furttenbach En De 'Holländische Nave'*. «Tijdschrift voor zeegeschiedenis», vol. 17, n.º 1, p. 3-14.

UNGER, Richard W. (1978) — *Dutch Shipbuilding before 1800: Ships and Guilds. Aspects of Economic History. The Low Countries*. Assen: Van Gorcum.

_____ (1985) — *Dutch Design Specialization and Building Methods in the Seventeenth Century*. In CEDERLUND, Carl Olof — *Postmedieval Boat and Ship Archaeology.* Oxford: B. A. R., p. 153-164.

_____ (2010) — *Ships on Maps: Pictures of Power in Renaissance Europe*. Houndsmills, Basingstoke, Hampshire; New York: Palgrave Macmillan, 2010.

_____ (2011) — *Dutch Nautical Sciences in the Golden Age: The Portuguese Influence*. «E-Journal of Portuguese History», vol. 9, n.º 2, p. 68-83.

_____ (2013) — *The Technology and Teaching of Shipbuilding, 1300-1800*. In EPSTEIN, Stephan R.; PRAK, Maarten Roy; ZANDEN, J. L. van — *Technology, Skills and the Pre-Modern Economy in the East and the West Essays Dedicated to the Memory of S.R. Epstein. Global Economics History Series*. Leiden: Brill, vol. 10, p. 161-204.

VERMEERSCH, Jeroen; HANECA, Kristof (2015) — *Construction Features of Doel 1, a 14th-Century Cog Found in Flanders*. «The International Journal of Nautical Archaeology», vol. 44, n.º 1, p. 111-131.

VERMEERSCH, Jeroen; HANECA, Kristof; DALY, Aoife (2015) — *Doel 2: A Second 14th-Century Cog Wrecked in Den Deurganck, Doel, Belgium*. «The International Journal of Nautical Archaeology», vol. 44, n.º 2, p. 327-348.

VOGEL, Walther (1911) — *Ein Neuendecktes Lehrbuch der Navigation und Des Schiffbaues aus Der Mitte Des 16. Jahrhunderts*. «Hansische Geschichtsblätter», n.º XVII, p. 370-374.

WARD, Robin (2009) — *The World of the Medieval Shipmaster: Law, Business and the Sea c.1350-c.1450*. Woodbridge; Rochester: Boydell Press.

ZANDEN, J. L. van (1993) — *The Rise and Decline of Holland's Economy: Merchant Capitalism and the Labour Market*. Manchester; New York: Manchester University Press.

III

SHIPBUILDING HERITAGE AND SOCIAL AWARENESS

POLITICS AND THE PORTUGUESE UNDERWATER CULTURAL HERITAGE

FILIPE CASTRO

INTRODUCTION

Portuguese elites never cared much about the country's cultural heritage. In the 19th century Portuguese authors such as Eça de Queirós and Ramalho Ortigão addressed this frustrating reality. With characteristic irony, Eça de Queirós described in *A Ilustre Casa de Ramires* the absolute incomprehension and disdain of the nobleman Gonçalo Ramires for his own family past:

> *Bento looked at the floor and then closed his eyes, thinking. «Yes. In the bathroom, above the red chest there was a flask with powder, wrapped in an old parchment, like those in the Archive». «That's it!» Gonçalo declared «I needed some documents in Lisbon, because of that dreadful problem with the rent from my Praga farm, and by mistake, in the rush, I took a perfectly useless parchment from the Archive. Fetch me the package, but be careful with the flask»*[1].

Ramalho Ortigão eventually dedicated an entire book to this subject — *O Culto da Arte em Portugal*[2] — where he painfully detailed a long list of crimes against the cultural heritage, and the absolute incomprehension and disdain of politicians, journalists, and the general public towards Portugal's ruins, monuments, archives, and history. Ortigão

[1] QUEIRÓS, 1900: 38. ed.
[2] ORTIGÃO, 1896.

details a long list of destructions perpetrated in the name of convenience, or just through abandonment and public ignorance.

The submerged cultural heritage is perhaps in a worse situation today, largely because it is invisible. Sometimes looted, other times abandoned by the responsible agencies, the Portuguese submerged cultural heritage was ignored throughout most of the 20th century. In the last two decades of that century it received some political attention and financial support, but the state did not manage to win the trust and the interest of the public and natural stakeholders, such as the Navy, museums, universities, fishermen, sport divers, or coastal municipalities. The secrecy and infighting that characterize traditional Mediterranean archaeology was championed in Portugal by a small group of archaeologists whose relentless refusal of the idea that the public administration exists to serve the citizens created a dysfunctional situation where looters were often the only active groups. In his Introduction[3] to the *Oxford Handbook of Maritime Archaeology*, George Bass pointed out that, as a class, archaeologists have a track record of negligence: it seems that we publish about 25% of the sites we destroy. Bass' assumption is based on a number of studies suggesting that over the last 50 years less than 25% of the materials and results of professional archaeological excavations have been properly published[4], 70% of the Near East excavations have not been published[5], and that perhaps 80% of all Italian archaeological materials remain unpublished[6]. It is difficult to argue that the situation in maritime archaeology is better than those mentioned above. As a result, publications are scarce and not very informative, access to images and reports is difficult, and archaeologists sometimes sit on their sites for decades, without digging or publishing whatever information has been retrieved. In this context, a long list of sites awaits intervention, and some are probably lost forever.

The state agency that controls maritime archaeology — the Direção Geral do Património Cultural (DGPC) — continues to see its role as a gatekeeper of the cultural heritage and never developed a vision or a plan, shared its intentions with the public, explained its policies, setup clear rules, or announced a strategy for the management of the underwater cultural heritage in the country. Moreover, public workers within that agency exert what little power they have with a notorious lack of accountablity, using the bureaucratic rules to persecute some archaeologists and support others, and creating a shameful partisan policy that Brazilians describe with irony as: «*Ao inimigo: a lei!*» (To the enemy: the law!).

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[3] BASS, 2011.
[4] BOARDMAN, 2009.
[5] ATWOOD, 2007; OWEN, 2009.
[6] STODDART & MALONE, 2001.

1. SHORT OVERVIEW OF THE PORTUGUESE SITUATION

A long list of underwater archaeological sites has been reported found by the media, or among sport divers over the last century, but published information is scarce and not always reliable. In the past 50 years shipwreck sites were reported along the Portuguese coast, at Caminha, Viana do Castelo, Esposende, Vila do Conde, Porto, Aveiro, Figueira da Foz, Nazaré, São Martinho do Porto, Baleal, Peniche, Ericeira, Porto Dinheiro, Praia da Samarra, Magoito, Cabo da Roca, Cabo Raso, São Julião da Barra, Paço d'Arcos, Lisbon, at the Tagus Mouth, Caparica, Setúbal, Sines, Arrifana, Carrapateira, Sagres, Lagos, Portimão, and along the coast of Algarve, as well as in the Azores and Madeira Archipelagos. The information about most of these sites is however scarce and often published in newspapers and magazines. The best overview published so far is still Mónica Bello's popular book *A Costa dos Tesouros*[7], and I am not aware of any ongoing or planned effort to study and share the Portuguese submerged cultural heritage, raise awareness, involve the stakeholders, and cherish this important layer of our common past.

During the 1980s Francisco Alves, director of the National Museum of Archaeology, started an inventory of the underwater cultural heritage by systematically collecting information on underwater sites, artifacts brought up by fishermen and sport divers, and historical accounts of shipwrecks, all in the same database. In the 1990s, however, the Portuguese government inexplicably ignored Francisco Alves' efforts and achievements, and in 1993 legalized treasure hunting and welcomed a crowd of international crooks, thieves, and liars, who proposed an array of delirious schemes — such as «raising a caravel» — to an amazingly uneducated and naïve committee of politicians and naval officers. The treasure hunting law — Decreto-Lei 298/93, of August 21st — ignored the basic tenets of archaeology and established an environment in which the Portuguese Navy was supposed to regulate and oversee the extraction of artifacts from archaeological sites. This surrealistic situation was reverted in the mid-1990s, when a newly elected government repealed the treasure hunting legislation — before any licenses were issued — and created a state agency for the management and protection of the country's submerged cultural heritage.

The Centro Nacional de Arqueologia Náutica e Subaquática (CNANS) lasted less than a decade, however, and is now downsized and largely inoperative, stripped of most of its funding and, as I am writing these lines (May 2017), not even staffed by a single nautical or maritime archaeologist. Busy with infighting and bogged down by small politics, ignorance, and an absolute lack of leadership, the Centro Nacional de Arqueologia Náutica e Subaquática doesn't seem to have much time or interest in defining its mission, nor organizing (and energizing) the Portuguese archaeologists and get them to work on a plan resulting from a vision and a national long-term strategy.

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[7] BELLO, 2005.

2. THE STRATEGIC IMPORTANCE OF THE PORTUGUESE SUBMERGED CULTURAL HERITAGE

It is difficult to imagine a healthy society oblivious about its past[8]. A country or region's cultural heritage is the base for its identity, its social glue, which is based on community feelings, and it confers a sense of meaning and continuity in a world that is increasingly more diverse and integrated, and where demographics are increasingly dictated by migrations and economic imperatives.

Studies in urban planning have shown that familiarity is an important element for the quality of life, and that most people are happier in an environment that conveys a sense of belonging, permanence, and stability. The cultural heritage is an intangible but integral part of the environment, sometimes referred to as the soul of a landscape. Monuments and popular memories or traditions convey a sense of a common past, encompassing good and bad memories, and fostering creative intellectual discussions based on interpretations of historical events, collective memories or amnesias, sometimes sanitized or embellished, sometimes demonized and charged with negative feelings. History is a source of wisdom. Howard Zinn once said that if we don't know our past we will have to trust our politicians, a joke that contains a deep and important truth.

Like its associated narratives, the cultural heritage is continuously being created and destroyed. War is a major cause of destruction, together with greed. Political and religious forces determine what should be preserved and destroyed, and economic development is a major cause of change, often with a tremendous impact on culture and the cultural heritage narratives.

As communications make the planet smaller, the world appears more complex and layered. Landscapes are in continuous change, preserving, changing, destroying and renewing themselves, a process that results in complex and layered mixes of old and new constructions and memories. To make sense of these landscapes is often an exciting and polemic intellectual process, which creates opportunities for learning and rethinking both the past and the present.

3. GLOBALIZATION AND THE HUMANITIES

This intellectual process is happening, however, in a difficult social context. In the late 20th and early 21st centuries, in the western world, wealthier people engaged in an ideological war against the common good and organized and funded a remarkable movement advocating a sharp reduction of the tax burden of the wealthier classes, a reduction of the public function, and a transference of the tax burden to the middle and lower classes[9].

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[8] CASTRO, 2015.
[9] WILKINSON, 2005.

This political process had an important effect on the size of the state and the services it provides. Infrastructures were privatized and turned into for-profit businesses, the social responsibility of corporations was greatly reduced, the media was bought and controlled by a small number of wealthy international players, and pro-small-government lobbyists flooded newspapers, magazines, and televisions, effectively instituting what has been called a monolithic global thought in which the public function is demonized and the private sector idolized. The result of this concerted international effort was that throughout the last decades of the 20th century and early decades of the 21st, the political spectrum moved sharply to the right[10].

In present politics greed and selfishness are often treated as social virtues, and governments are no longer seen as the referees of conflicts in society, but rather as the representatives of a wealthy international minority whose main role is to facilitate trade and economic growth. These policies are affecting the preservation, study, conservation, and divulgation of the cultural heritage everywhere. Contractors that previously had to account for the potential destruction of the cultural heritage impacted by their work gained bargaining power, public watchdog agencies were defunded and crippled by the threat of lawsuits, museums were forced to close or de-access collections, conservation laboratories were forced to raise prices for treatment, dating, and testing of artifacts.

The study of the humanities is under attack, mostly in the Anglo-Saxon world, but the global reduction of resources for the study of the human adventure is affecting other countries and cultures as well, as the media boasts the need for more investment in science, technology, engineering, and mathematics (STEM), at the cost of the humanities and social sciences.

4. THE EUROPEAN MODEL

In this context, the submerged cultural heritage was perhaps hit harder, because it is submerged and therefore invisible. With a few exceptions, such as Spain or France, for example, maritime archaeology was taken off the top priority lists by many governments. Submerged cultural sites are regularly destroyed by real estate promoters, building or dredging contractors, trawling, harbor works, looting, and treasure hunting, a legalized version of looting invented in the USA in the 1970s.

The defunding and privatization of education also impacted the cultural heritage. As mentioned above, in the west, archaeologists publish about 25% of the sites they excavate, and thus destroy. This sad reality was further hampered by the defunding of state scientific agencies and research institutions, and in this environment grants are increasingly competitive and smaller, and archaeologists are incapable of raising funds for archaeological excavations. This situation is perhaps worse for underwater excavations,

[10] POWEL, 1971.

because waterlogged artifacts require extra care, which costs extra money. Additionally, archaeology is a relatively recent discipline, still plagued by amateur attitudes and behaviors. Many archaeologists still treat their excavations as personal property, don't publish and advertise their discoveries, don't share their primary data, tend to organize in small groups and engage in tribal wars over trivial matters. Archaeologists typically treat their data and their pictures as important secrets, sometimes delay publications, and traffic archaeological information within small groups. This environment makes it difficult to develop the idea that archaeology has some sort of social value for the wider public.

Some countries have agencies that try to organize the research along top-down strategies, and end up preventing younger archaeologists from digging or publishing, restricting a healthy dialogue that the discipline desperately needs. Moreover, the petty secrets and petty fights between archaeologists alienate politicians, journalists, the public, and some of the most important stake holders, such as sport divers, fishermen, the country's navies, local authorities, museums, and diving clubs.

In spite of this grim situation, however, there seems to be a wide consensus about the importance of preserving a country's cultural heritage: most stakeholders seem to agree that educated societies are stronger, healthier, happier and smarter. The larger the middle class, the better educated societies are, and the better quality of life they promote. Middle classes are actually growing around most of the planet, even if they are being compressed and impoverished in the west, and inequality is affecting the west perhaps as much as the rest of the planet.

Middle classes have shrunk in the US and Europe for a generation now, and as they are the main consumers of cultural goods and productions — libraries, museums, concert halls, orchestras, opera houses, literary magazines, books, etc. — these cultural goods are under pressure. Still, the tourism industry looks like a profitable solution for this problem, because with middle classes shrinking or not, cultural tourism is still an appealing source of income for many countries.

In spite of all these global problems, and of the dangers for freedom and democracy posed by the accumulation of wealth by a small international elite, the developing world is reacting with impressive vigor, profiting from a small reduction of the planet's hopeless poverty, and the rise of literacy, which is today almost 100% among the world population below 25 years of age.

It is interesting and exciting to imagine a world in the near future where the mainstream philosophers, historians, archaeologists, sociologists, scientists, and artists will likely be non-European. Diversity and plurality foster creativity, and the archaeology of the last century was predominantly European in its views, assumptions, research questions, and practices[11]. As Geert Hofstede put it, culture is the software of the mind, and

[11] HODDER, 2011.

culture pre-establishes the sets of outcomes of any research project. American philosopher Daniel Dennett likes to quote one of his students, B. Dahlbom, who said that one «can't do much carpentry with bare hands, and can't do much thinking with a bare brain»[12].

He brought up this subject many years ago: our brains think better and faster when we learn thought processes he called thinking tools and intuition pumps. According to Dennett, thinking tools and intuition pumps «are apps that we upload to our necktops», and societies are as smart as the thinking tools available in them. James Flynn[13] had demonstrated that, with exactly the same bare brains, we score much higher today in IQ tests than we did 80 years ago. It is culture that is making us smarter. The cultural heritage is a powerful source of thinking tools, and any investment in its study and protection will help create a smarter and more sophisticated society. And cultural identity ensures some level of diversity in the globalized world.

As already mentioned, tax cuts on the wealthier are putting pressure on governments to reduce public funding for research. A lot has been written since the 1970s on the necessity of taxpayer-supported research and art production. Creativity is an important component of the scientific process[14].

Diversity and plurality of ideas are valued differently from country to country and through time. For instance, presently America and Europe advocate small government and deregulated capitalism, although continental Europe still defends that a society dominated by markets offers less individual and social options. In 2005, American composer William Osborne noted that «Germany's public arts funding, for example, allows the country to have 23 times more full-time symphony orchestras per capita than the United States, and approximately 28 times more full-time opera houses». This is a well--studied phenomenon: the tastes of the more educated minorities have no economical appeal for most private sponsors. Unless the public is rich and can pay the full price of production of a four-hour opera, for instance, it is impossible to imagine how the cost of such a production can be met without public subsidies. The same can be said for graduate studies, museums, the performing arts, and archaeology.

A good example is precisely maritime or nautical archaeology. For television producers and shareholders, archaeology can rarely compete with treasure hunting for audiences. Shallow and glowing stories of sunken treasures, with ghosts, sea monsters, and invented anecdotes, ensure wider audiences over any archaeological documentary anytime, anywhere. Archaeologists are bound by ethical principles and cannot lie, embellish their stories, or propose exciting unproven hypotheses that seduce the large public to watch their documentaries in numbers large enough to justify the interest of advertising companies.

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[12] DENNETT, 2013.
[13] FLYNN, 2012.
[14] KUHN, 1962.

Although the dumbing down of the media is noticeable, the level of the cultural production is not as infantile as in the USA, where widely watched channels, such as the *History Channel* or the *Discovery Channel,* regularly broadcast documentaries about fake monsters, aliens, or ghosts without the slightest care for truth or reason. In Europe the situation is not yet as egregious. For instance, 95% of the funding for the Franco--German television channel ARTE — which broadcasts exclusively cultural programs — comes from a television tax. Paris is famous for its large and widely advertised budget for public projects. Its museums and exhibitions are world famous and fuel the largest tourist industry in the world, worth 7% of the country's GDP[15]. The French policy of promoting a state idea of culture, sponsored by taxpayers' money, has been maligned by the populist right-wing since the early 1990s[16], but their viewpoint did not yet won the support of the public opinion, and has been largely ignored.

The prevalent idea in Europe is still that in democracy the population should have access to an as-wide-as-possible diversity of cultural goods because society is an organism that cannot survive without intellectual elites, and because educating, training, stimulating, and recruiting intellectuals requires taxpayer-supported research. Additionally, Europeans still cling to the idea that unfettered capitalism tends to destroy traditional culture and ways of living. Based on advertising, which promotes acritical compliance and aims at destroying diversity and independent thinking, unregulated capitalism is still considered a leveling force that pushes a one-size-fits-all model for society and makes the world homogenous (e.g. Microsoft, Google, or Starbucks). Maximizing profit while maximizing the diversity of products offered is ultimately impossible, and many Europeans believe that savage capitalism breads alienation, uniformity, and conformism.

5. A STRATEGY FOR PORTUGAL

Portugal is a poor country, with a weak economy and under constant pressure from international agencies to lower its public budget and diminish the size of the state. Large cultural policies are out of the question. The vicious cycle of lack of education and critical thinking makes the public ask more football and less cultural productions. In this context, what can Portuguese archaeologists do to protect, study, preserve, and exhibit its cultural heritage? How can they compete with other countries for cultural tourism, the best and most reliable source of income generated by the cultural heritage? These questions have a vast array of practical answers with different costs and time frames. But the key factor in cultural policies seems to be a strong commitment to long-term strategies.

[15] FRANCE DIPLOMATIE, 2013.
[16] FUMAROLI, 1991.

What can Portugal offer to the cultural tourism industry? Shipwrecks *in situ* are mostly invisible and cannot be exposed to the elements indefinitely. And it is relatively easy to bring a crowd to a museum once, for a major exhibition, but to make them keep coming regularly is not a trivial problem.

Touristic countries such as Portugal can aim at the creation of museums designed to be visited by one-time tourists, and keep the internal markets in mind, at a smaller scale, creating exhibitions that can excite the Portuguese public repeatedly. It seems safe to assume that artifacts belong in one-time museums, and installations and temporary exhibitions are better suited to interest the public repeatedly and regularly.

The first step for an effective strategy should be an assessment of the situation. The publications, exhibitions, and on-line resources available — such as the DGPC website *Endovélico* — seem incomplete and not terribly organized. For instance, for the submerged cultural heritage it encompasses both archaeological sites and documental data pertaining to ship losses. The levels of information vary and sometimes there is no bibliography on the sites inventoried. It would be useful to organize a joint effort, involving the DGPC, the municipalities, and the Navy, and develop and share municipal inventories, independent and detailed, with the sites separated from the archival data, to encourage a decentralized model, based on the local communities, and if possible involving the populations.

The second step would be to promote the development of a specific national database of submerged archaeological sites, with a diagnostic of the global situation, and prognostics per municipality, with emergency plans of action and budgets. In other words, to produce documents detailing the potential value of the submerged sites, their situation in terms of threats and opportunities, and the costs associated with not doing anything, promoting palliative and protective care, surveys, or intrusive interventions.

The third step would be to promote cultural tourism in Portugal and subsidize a few flag projects, perhaps based on a small number of selected interesting stories, rather than on the archaeological sites. Archaeology brings the past back and allows the public to look at itself against different backgrounds. It makes people think and it provokes emotional reactions. Vast collections of artifacts and expensive exhibitions are not necessary in the age of computer graphics. The question of the value of artifacts is complex and difficult to address. What is it that makes us value genuine archaeological artifacts or works of art over replicas? Most people agree that to have the real objects that connect them to past events will help them feel and relate more intimately with those events. The value of the original archaeological artifacts poses, however, questions that archaeologists need to address. Archaeologists destroy the sites they dig and try to record them layer by layer, but all representations of excavated sites are virtual by definition. They are traditionally expressed through plans and sections, and now through 3D computer files, photogrammetric meshes of points, and virtual reality environments.

Artifacts, now as ever, pepper our narratives and help us land life and reality to them. But the stories are told through our drawings and texts, and those can be treated and shared in spectacular ways in museums for prices that are lower every year.

Perhaps we should protect our sites *in situ* as much as we can, hoping that one day our descendants will have non-intrusive technologies that will allow a better understanding of the sites we are digging today. And if so, we could share what we know in museums and exhibitions that are relatively cheap to develop including new technologies, such as virtual and augmented reality. Moreover, to share the wealth of historical data that each kilometer of waterfront in our country holds with school children and the public in general would be the best way to protect it. Websites, small temporary exhibitions, on-line databases and associations of divers, dive clubs, grassroots organizations encompassing biologists, sport divers, archaeologists, local managers, scholars, and policemen are the best way to ensure that each municipality's submerged cultural heritage is valued and protected. The archaeology of the 21st century should be an archaeology of shows and discussions, and local, public, critical, didactic, and community archaeology.

During the 19th and 20th century scholars have developed an impressive work, inventorying and studying European archives, monuments, and artistic treasures. Francisco Contente Domingues has published a story of the late 19th and 20th century scholarship in this domain and the bibliography available is impressive, both by its extension and its quality.

The majority of the most important documents pertaining to the Portuguese exploration of the world in the 15th and 16th centuries are transcribed, published, and studied, and the naval history bibliography constitutes a solid base for the study of ship typologies, design, construction, rigging, and sailing. The body of publications about life aboard and the mentality and social status of the soldiers, sailors, captains, pilots, shipwrights, merchants, intellectuals, and remaining stakeholders is less complete, and has space to grow.

There is no reason why Portugal should not explain and divulge its maritime past to the world and use it as an appealing foundation for the development of cultural tourism. I am not advocating a return to the jingoistic narratives of the Estado Novo (1926--1974). On the contrary: I am proposing a cosmopolitan narrative which acknowledges the good and the bad sides of all contacts between civilizations, without ham-handed interpretations and moralist judgements. Portugal played a central role in an amazing period of the history of humankind: the globalization of the 16th century and this is a story with profound implications in the histories of science, of the ideas, of art, and of culture. Contacts between civilizations that were violent to begin with were often violent, but they were also exciting and almost nobody is interested in telling the good side of that story.

6. A FEW THOUGHTS ON CONSERVATION

Given the state of the art conservation techniques we have today, some colleagues argue against the musealization of wooden structures from shipwrecks because the technologies we have today do not guarantee the preservation of these structures forever. But conservation *in situ* is an expensive strategy that requires periodic inspections, databases, assessments, diagnostics, prognostics and action plans. Few governments would invest the necessary means on such projects, which require the allocation of resources now to preserve a cultural heritage society cannot enjoy and leave it to future generations, so that they can have a better environment with better preserved archaeological resources. This discussion is impossible in abstract terms. Every case has its specificities and each solution to dig or cover and protect *in situ* should be carefully chosen, on a case by case basis.

I would argue that the social value of the cultural heritage can be expressed in present knowledge, which should be shared with an as-wide-as-possible public. The 2001 UNESCO Convention on underwater cultural heritage states in Article 20 that «Each State Party shall take all practicable measures to raise public awareness regarding the value and significance of underwater cultural heritage and the importance of protecting it under this Convention». This idea is further developed in its Annex, Titles XII and XIV: «Interim and final reports shall be made available according to the timetable set out in the project design, and deposited in relevant public records»; and «Projects shall provide for public education and popular presentation of the project results where appropriate», respectively. This is the most important component of any professional study of the underwater cultural heritage. The social value of archaeology lies on a wide divulgation of archaeological finds, aimed at plural and diverse publics, and fostering discussion about the past, which is not an established reality, but a reconstruction that every generation of scholars attempts.

Conservation *in situ* can be — and has been — an alibi for stasis and irresponsible abandonment of the cultural heritage to the elements. Shipwrecks and submerged structures must be surveyed, entered into management databases where their condition is recorded and diagnostics and prognostics can be made, and actions planned and budgeted, but I do not believe that societies should prevent their scholars from digging, studying, publishing and sharing their views of the past. The current trend, which sometimes seems to encourage preservation *in situ* at any cost, even without the mechanisms to assess the condition of the shipwrecks preserved *in situ*, has a dangerous prohibitionist component. In certain countries, such as Portugal, to cite just one example, the conservation *in situ* argument was used to stop almost every excavation in the past 20 years, and the text of Rule 1 of the 2001 UNESCO Convention on Underwater Cultural Heritage was stretched to impede archaeological research. Rule 1 states that the authorization of activities directed at underwater cultural heritage must be justified only if they make «a significant contribution to protection or knowledge or enhancement of underwater cultural heritage». The word «significant» grants enormous latitude to permitting agencies.

I would argue that conservation *in situ* is a particularly important issue after sites are excavated or looted. Most archaeological sites are or should be reburied as there are not enough museums in the world to house every archaeological find. The past should not rule the present in that sense. It is impossible to preserve everything and we are only expected to do our best. Once sites are excavated, some are treated, conserved, exhibited in museums and their collections curated. Others are stored in warehouses, where they are sometimes forgotten. Others are reburied, and their condition should be monitored. Excavation is a very destructive process. The exposure of buried timber changes its biochemical environment and the excavation process is often abrasive and destructive. Whatever is left on the bottom must be reburied, stabilized, protected from looters, dredge works, land fillings, and trawlers, to cite just a few threats.

7. RECORDING

Technological advances in tridimensional recording and representing made it quicker and cheaper to assess and record archaeological sites, and keep them as virtual models, which can be shared with the general public, their colleagues, and used to encourage further research. Buried sites do not have to be forgotten and completely out of reach: in fact, they can be shared on the internet, integrated in computer games, classes, movies, documentaries, and popular publications.

We should not be deterred by the fear of misuse of archaeological information. The best policies to protect a community's cultural heritage is to share it, to let it be photographed, recorded, copied, circulated, discussed and published freely. Bad interpretations are a part of lie. They have always been around and will never go away. Some of the worse interpretations have been developed by professional archaeologists. It is not possible to place a policeman behind every citizen, and a policeman behind every policeman, and nobody can say which interpretations are entirely correct, to start with.

Archaeologists are sometimes afraid of allowing free circulation of images and primary data for a number of reasons: fear of plagiarism, fear that their images might be published to illustrate fake theories and stories, fear that images get commonplace and banal, and fear that their primary data may be found flawed or used to contradict their conclusions. These fears are largely unfounded. Archaeologists record and interpret remains of past human activity. Few professions are as subjective as ours and we should get used to it. Firstly because few archaeological sites or complexes are complete, secondly because we cannot record everything and we end up recording what we deem important, and thirdly because even if we were flawless, the accuracy of our recordings depends on the precision of our tools. Archaeological interpretations are iterative and change every generation, regardless of the outlandish theories that might or might not be published, illustrated with our pictures.

Philosopher Avital Ronell said that we cannot build a mirror that reflects our stupidity and therefore we should be humble and careful[17]. This is a particularly valid piece of advice for archaeologists. Sharing our discoveries early and with a wide set of peer reviewers is paramount to the success of an excavation. A plurality of ideas and viewpoints is the best assurance against committing serious mistakes. And archaeology must be public or it has no social value and should not be funded with tax-payer's money.

8. EXCAVATION

Excavating is expensive and generates artifact collections that need to be conserved and curated forever. It is difficult to advocate the necessity of increasing the national archaeology budget, even in countries that waste billions of euros in pharaonic projects such as football championships or in weapons for war games, but salvage and mitigation works are regulated and are payed for by the entities that destroy the archaeological sites.

In the present political conjuncture contract archaeology should represent the core of the excavations, as it happens in most countries around the world. This is a perfectly functional situation, where young archaeologists can be trained. Perhaps the only improvement to hope for is the outreach component. All contract archaeology works should aim at being community projects, involving the local and interested populations.

Primary data should not, however, be secret and considered property of the archaeologists in charge of a project. Portuguese law already establishes the necessity of making primary data public after a certain number of years, and archaeologists should strive to develop a culture of cooperation and respect, where primary data and images are widely shared and publications come out in a timely manner.

The evolution of ideas is wasteful and feeds on the chaos and randomness of brainstorming. Creativity has always been a part of archaeological thought, and excavations should be as transparent as possible. Cooperation with artists, schools, editors, and other stakeholders should be encouraged and brokered by the municipalities. Ian Hodder demonstrated that his work at Çatalhöyük was enjoyed by local and international constituencies at many different levels, some of which pathetic, like the Turkish nationalist interpretations — there were no Turks in Turkey for another 8,000 years after Çatalhöyük was abandoned — or the cult of the goddess developed by American tourists. But his position as an archaeologist was just that of sharing, to the best of his knowledge, and with as much openness as possible, everything he found, and let the world enjoy it in its own way[18].

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[17] RONELL, 2002.
[18] HODDER, 2011.

The cooperation between artists and archaeologists also presents some natural space for growth.

CONCLUSION

Portugal has a long maritime past, a beautiful coast and a rich submerged cultural heritage. The history of the country's maritime past is studied but not divulged at a popular, international level, mostly when we think about the 15th and 16th centuries scientific advancements, the rise of anthropology, the discovery of the planet, the development of botany, chemistry, zoology, philosophy, and the profound changes the Iberian navigations triggered in European culture.

Archaeology, and specifically nautical archaeology, can help us understand our past and our long and sometimes forgotten relation with the sea, and the study of the shipwrecks in our coasts, compounded with the study of Portuguese shipwrecks around the world, can be the core of a long term cultural strategy in which the submerged cultural heritage can be the foundation of a series of learning environments for schools, high schools and universities, and a relevant touristic attraction.

In summary, computers can be at the core of this strategy, for a number of relevant reasons:

1. The submerged cultural heritage (SCH) is invisible and 3D modeling can make it visible to a wide audience;
2. Digital video and photogrammetry can help monitor and protect sites preserved *in situ*;
3. Shipwrecks are not stable archaeological sites (looting, treasure hunting, economic development, trawling, natural disasters) and digital recordings can preserve their image forever;
4. Digital archaeological sites can be scaled, sliced, tagged — augmented reality — and shared online, serving as interactive learning environments and as the base for international research;
5. Tridimensional renderings can be layered and decompress the time enclosed within, for instance with animations of changing landscapes, architectures, or site formation processes.

Computers and computer science are changing archaeology, making it easier, cheaper, plural, and offering the possibility to establish didactic and community archaeology projects with low budgets.

It is plausible to assume that Autonomous Underwater Vehicles (AUVs) will become cheaper, carry better payloads, have increased autonomy, and will be easier to deploy. Sub-bottom profiling will evolve in the next decades to create the underwater equivalent to CT scanning, and multi-beam sonar will generate cheaper and better images, and these tools will make it easier and cheaper for state and local agencies to survey the bottoms along the coasts and rivers of the entire country and establish an hierarchy of sites needing protection, palliative care, recording, study, or even intrusive interventions.

It seems that, more than ever, what we need is leadership, a participated and democratic model in which the role of the state will be facilitating and regulating, and the work left to the municipalities in cooperation with museums, universities, dive clubs, and the Navy.

EDITED SOURCES

ATWOOD, R. (2007) — *Publish or be Punished: Israel Cracks Down of Delinquent Diggers*. «Archaeology», vol. 60, n.º 2, p. 18, 60, 62.

BASS, G. (2011) — *Introduction*. In CATSAMBIS, A.; FORD, B.; HAMILTON D., *eds*. — *The Oxford Handbook of Maritime Archaeology*. New York: Oxford University Press.

BELLO, Mónica (2005) — *A Costa dos Tesouros*. Lisbon: Círculo de Leitores.

BOARDMAN, J. (2009) — *Archaeologists, Collectors, and Museums*. In CUNO, J., *ed*. — *Whose Culture? The Promise of Museums and the Debate over Antiquities*. Princeton: Princeton University Press.

CASTRO, F. (2015) — *The re-utilization and preservation of underwater cultural heritage. In Proceedings of the International Conference on Preservation and Management of Underwater Cultural Heritage for the Ministry of Culture,* October 3-7, 2015. Taiwan: Ministry of Culture.

DENNETT, D. (2013) — *Intuition Pumps and Other Tools for Thinking*. New York: W. W. Norton & Company.

FLYNN, J. (2012) — *Are We Getting Smarter? Rising IQ in the Twenty-First Century*. Cambridge: Cambridge University Press.

FRANCE DIPLOMATIE (2013) — *France, the world's leading tourist destination*. Available at <http://www.diplomatie.gouv.fr/en/french-foreign-policy/economic-diplomacy-foreign-trade/facts-about-france/one-figure-one-fact/article/france-the-world-s-leading-tourist>. [Accessed on 09/2015].

FUMAROLI, M. (1991) — *L'État culturel, essai sur une religion moderne*. Paris: Éditions de Fallois.

HODDER, I. (2011) — *Çatalhöyük: The Leopard's Tale*. New York: Thames and Hudson.

KUHN, T. S. (1962) — *The Structure of Scientific Revolutions*. Chicago: University of Chicago Press.

ORTIGÃO, J. Ramalho (1896) — *O culto da Arte em Portugal*. Lisbon: António Maria Pereira.

OSBORNE, W. (2004) — *Marketplace of Ideas: but first, the Bill*. «Arts Journal». Available at <http://www.artsjournal.com/artswatch/20040311-11320.shtml>. [Accessed on 09/2015].

OWEN, D. (2009) — *Censoring Knowledge: The Case for Publication of Unprovenanced Cuneiform Tablets*. In CUNO, J., *ed*. — *Whose Culture? The Promise of Museums and the Debate over Antiquities*. Princeton: Princeton University Press.

POWEL, L. (1971) — *Confidential Memorandum. Attack on American Free Enterprise System. Typed Report*. Available at <http://law2.wlu.edu/deptimages/Powell%20Archives/PowellMemorandumTypescript.pdf>. [Accessed on 05/2017].

QUEIRÓS, J. Eça de (1900) — *A Ilustre Casa de Ramires*. Lisbon: Livraria Chadron.

RONELL, A. (2002) — *Stupidity*. Chicago: University of Illinois Press.

STODDART, S.; MALONE, C. (2001) — *Antiquity*. «Editorial», vol. 75, n.º 288, p. 233-246.

WILKINSON, R. (2005) — *The Impact of Inequality*. London: Routledge.

THE PROJECT OF BUILDING A NEW TEA CLIPPER — THE *CUTTY SARK 2*

VLADIMIR MARTUS

Fig. 8.1. *Cutty Sark 2*
Source: courtesy of *Cutty Sark 2* Sail Foundation

INTRODUCTION

This paper's aim is to present the project of the construction of a new full-size sea-going cargo ship, a replica of the famous sailing tea clipper *Cutty Sark*. This vessel will serve several purposes, the main ones being:

Wind power: The first main purpose is to demonstrate to the world how, by harnessing the power of the wind, we could ferry various types of cargo across oceans as our ancestors did 300 years ago, without using fossil fuels or engines — thus contributing to a cleaner, more sustainable world.

Training professional sailors in the use of wind power: The second purpose is to train sailors, to provide them with the necessary professional and technical tools to effectively operate sailing ships. By this we do not necessarily mean only historical sailing ships but, indeed, any type of sailing ship that could be used for the shipping goods in the future. The plan is to preserve, and then to develop the skills and experiences related to the running of large square-riggers, or any other future vessel types which have wind power as its power source.

Culture and maritime heritage: The third main purpose is more culture-related: to preserve part of the world's maritime heritage — the most advanced and splendid sailing ships that humankind has created after many centuries of evolution. While constructing the new ship, a large number of traditional crafts and skills related to woodworking and shipbuilding will be recorded, preserved, developed and passed on to future generations.

These are the project's three key purposes. Now we will enlighten the reader as to the origins of this project, and intended ways forward to achieve success in our endeavor:

Our story starts many years ago in Russia, when a group of students came together and decided to build a full-size replica of a frigate with the aim of reminding people of St. Petersburg and of important episodes of their own history. This endeavor was in particular inspired by the story of Peter the Great, the Russian Tsar, who wanted Russia to have a powerful navy. His desire was so overwhelmingly strong that he decided that he would personally travel to other countries to learn the crafts and obtain the skills related to naval architecture and shipbuilding. He was not content with merely observing the artisans go about their work, though — he took the hands-on approach to the matter, working as carpenter alongside other professionals for several months at a shipyard in the Netherlands. After these experiences, he returned to Russia and built his first ship, the *Shtandart*, along with other sailing ships and boats. That was the beginning of Russian Navy — the great maritime powerhouse, the Vision of the Russian brought to life.

In 1992, a small team of students decided to build a replica of that historical ship — the *Shtandart*.

Fig 8.2. Replica ship *Shtandart*
Source: courtesy of Swedish Coast Guard

Fig 8.3. *Shtandart* constrution team in St. Petersburg (1999)
Source: Evgeny Mokhorev

This endeavor was supported by a large number of volunteers and international sponsors. Finally, the ship was constructed by young people who were learning traditional crafts and skills. There were all sorts of crafts involved in this process: carpentry, rope-making, sail-making, carving, blacksmithing, block-cutting, welding — in essence, all types of traditional skills necessary to the building of a full-size wooden sailing ship. The shipbuilding process took roughly 6 years to complete. By the time the *Shtandart* was launched in 1999, about 60 young craftsmen who had worked on the vessel had become highly skilled artisans. They still continue to ply their trade and to hone their skills. Recently, a replica of the *Poltava*, a Russian ship of the line, was built in St. Petersburg by the team responsible for the *Shtandart*.

It is only logical to continue this effort of preserving maritime skills. Hence, it seems fitting to turn to a more ambitious enterprise — the building of a larger and more exquisite sailing ship: a tea clipper.

1. *CUTTY SARK* THE TEA CLIPPER, AND HER STORY

Fig 8.4. *Cutty Sark* (1869)
Source: from collection of *Cutty Sark 2* Sail Foundation

All tea clippers were fast sailing ships, vessels that plied the tea-trading routes between China and Britain in the 1840s-1870s. There was large incentive to sail as fast as one possibly could: those who arrived in London with their cargo first were awarded a high premium and could demand higher prices for their merchandise. So, captains felt encouraged to navigate their ships at the fastest possible speed. Tea harvesting in China only took place at specific times of the year. In other words, one could not speed the whole process up; thus, all ships started on equal footing — that is to say, the cargo-loading process would take about the same time for every ship. They then would leave China's ports and off they went, at top speed, bound for Britain. It was like to a race; in fact, it was known informally as «the tea race» in Britain, a widely reported affair that garnered a lot of public attention. And so, to be in these circumstances encouraged the development (and constant refinement of) top-tier sailing-related techniques and skills — which, in turn, entailed improving the designs of the vessels, their rigging, the materials to allow them to be faster, etc. Tea clippers were the fastest and most elegant, the most splendid ships created by humankind. There was even a larger type of sailing ship created, the windjammer, after the tea clipper fell out of use. But this larger vessel was built with «industrial» purposes in mind, i.e., this type of ship was used to ferry coal, fertilizer and other kinds of heavy cargo in large quantities across the ocean. However, the tea clipper far outclassed the windjammer in terms of speed and grace. To put it in perspective, tea clippers were akin to Formula One cars in terms of speed and elegance, while windjammers were more like bulky and rather slow trucks.

The idea behind the *Cutty Sark 2* Project is to bring one of those magnificent, fast sailing ships to life again. And, after its construction, the goal is to load it and have it transport cargo without using any fuels, without producing any CO_2 emissions.

The original *Cutty Sark* still exists. However, the vessel will never take to the sea again; it was placed onto the dry dock and repurposed as a museum exhibit. This modern restoration makes the original *Cutty Sark* more akin to a museum building than an actual vessel; it lacks that peculiar aura of a real sailing ship. Hence, it would be far more interesting and engaging to the public at large if this sailing ship — with such a storied life, of such size, of such majesty in appearance — were to be restored to its natural element once again.

There are several examples of large replicas of historical ships built to brave the seas. The largest so far are France's *Hermiona*, the *Gothenborg* from Sweden and the Russian *Shtandart*. These are exquisitely built sailing ships; they drew the attention of many an individual during their construction phase. The vessels were the object of the media's — and, consequently, the public's — profound interest, for they were symbols; they illustrate and embody their people's history, the history of their forebears and the manner in which their respective countries came to be maritime superpowers. This is a more engaging and fascinating way to tell people about their roots.

Fig 8.5. Visitors watching *L'Hermione* constrution (2013)
Source: courtesy of Association Hermione La Fayette, Rochefort

The aforementioned vessels are generating a lot of buzz. And hence, we arrive at the subject matter of the present paper: the *Cutty Sark*. The story of the original *Cutty Sark* is intrinsically linked to Portugal; the *Cutty Sark* was acquired by the Portuguese and sailed under Lusitanian colors for 27 years, being christened as «Ferreira» during her period of service. And this link between the vessel and the country naturally led us to the idea of building the vessel in Portugal. Another reason for choosing Portugal as its place of construction lies in the fact that the country still retains its many highly skilled and renowned craftsmen, artisans who, to this day, work with wood, building and repairing wooden ships. More than in any other country, these crafts are alive in Portugal, especially in Vila do Conde. This small town has a rich tradition intimately linked with the sea, a history of shipbuilding, of ocean-going men, of fishing and of ship repairing and maintenance. And, in fact, the skills of the craftsmen found here are so superb that they ought to attain the intangible cultural heritage status and be preserved for future generations. These reasons led us to consider developing our project — the construction of a replica of that famous British-Portuguese tea clipper, that is — in the city of Vila do Conde, in Portugal.

Fig 8.6. Vila do Conde
Source: collection of Museu da Construção Naval, Vila do Conde

We do have quite an extensive experience in operating replica ships: we have been sailing the *Shtandart* for 17 years and we also possess an additional 10 years of experience in sailing other replica ships. And so, we have developed a business model and the technical description of what we should have in a new vessel to make her sustainable and self-sufficient, to bring her to life in all her glory, while having her generate enough income to cover the cost of her general upkeeping, as well as constructing — and always maintaining — her in all her majestic exquisiteness. The general idea is: since the ship is a replica of a much-loved and well-known ship, it will draw the public's attention; this means that any time the vessel is anchored in any given port it will attract myriads of visitors.

On the other hand, we are speaking of a large cargo ship — so, naturally, we will be able to ferry goods, goods that would attain a special status indeed, for they would be transported by wind power alone, which would attract the patronage of environmentally conscious companies who are invested in being publicly viewed as more environmentally-friendly.

Fig 8.7. *Tres Hombres* loading cargo for transportation under sails
Source: courtesy of Fairtransport Shipping and Trading

So, if these companies want to further their environmentally conscious image while requiring the transportation of merchandise, the *Cutty Sark 2* would be the ideal choice. This would be a secondary source of income and, of course, the affreighting of the vessel by companies would entail the creation of another business platform for promoting businesses in other countries. The sponsors and participants of the project would have the opportunity to use the ship as a means to promote themselves, their products, their businesses in her visits to other countries.

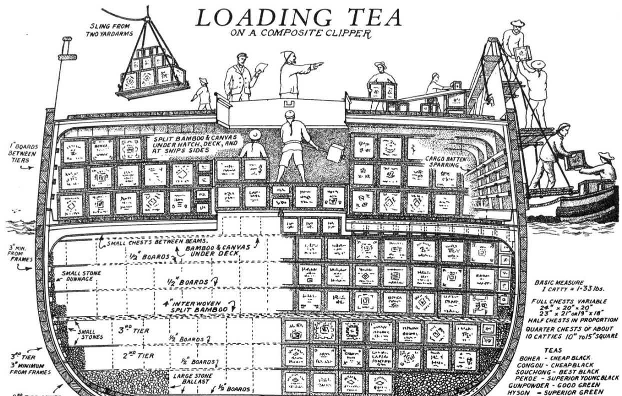

Fig 8.8. Loading tea in tea-chipper in China drawings of *Cutty Sark* sales and rigging
Source: CAMPELL, George F. (1974) — *China Tea Clippers*

The idea is to recreate historical journeys, *Cutty Sark*'s own historical routes from Europe, across the Atlantic Ocean and then around the Cape of Good Hope, bound for Sri Lanka or China or Australia, and the return journeys would be made either via the Indian Ocean or around Cape Horn. Every journey could be a round-the-world voyage. The project plan is for the ship to carry about 1000 tons of cargo. If the cargo happens to be tea or coffee or rum, it could be stored in the hold. The tweendeck would serve as living quarters for trainees. Our plan is to have up to 80 people on board: of these, up to 50 of these individuals would be trainees — young men and women (18-25 years old) —, tomorrow's sailors, who are to be instructed in the skills and techniques needed to become fine seamen.

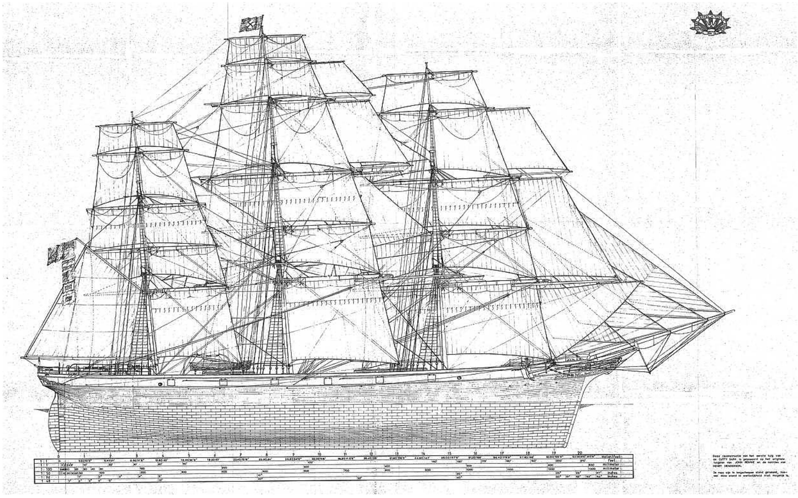

Fig 8.9. Drawings of *Cutty Sark* sails and rigging
Source: Drawing Nederlandse Vereniging van Modelbowers, 2010

Safety is always a major concern; and people might think — and rightly so, at first glance, at least — «oh, but sailing ships cannot be safe». This could not be further from the truth. Equipped with modern weather forecasting, communication equipment, navigational equipment, the crew will be able to know their position at all times and will always be aware of any danger that may threaten their security. This may be a replica of a 149-year-old ship but we intend it to be equipped with modern navigation and communication systems; it is not like we are still in the 19th century, a time when skippers had to make a guess whether they were on this side of the rope or on the other. So, to sail on this ship would be quite a safe endeavor! And we have the engineless cargo ship called the *Tres Hombres* as an example of that. This schooner brig already has 5 years of active operation under her belt, making several journeys a year across the Atlantic Ocean to the Canaries, bringing wine to Copenhagen, dried cod from Norway to Portugal and rum from the Caribbean to Europe. These voyages are extremely successful, and, while it is a tiny vessel, a reading of its profits and business model demonstrates that there is an interest and a demand for this sort of shipping. The *Cutty Sark 2* will be an even more successful venture. Presenting the story of the building of the ship and presenting the participants in foreign ports is another option. The *Cutty Sark 2* has a huge potential and, as it is a large, incredibly eye-catching vessel, it would make every visit to a port a really interesting and memorable affair for the local populations, for the media, for the audience — and we anticipate that our endeavor will attract a huge amount of publicity.

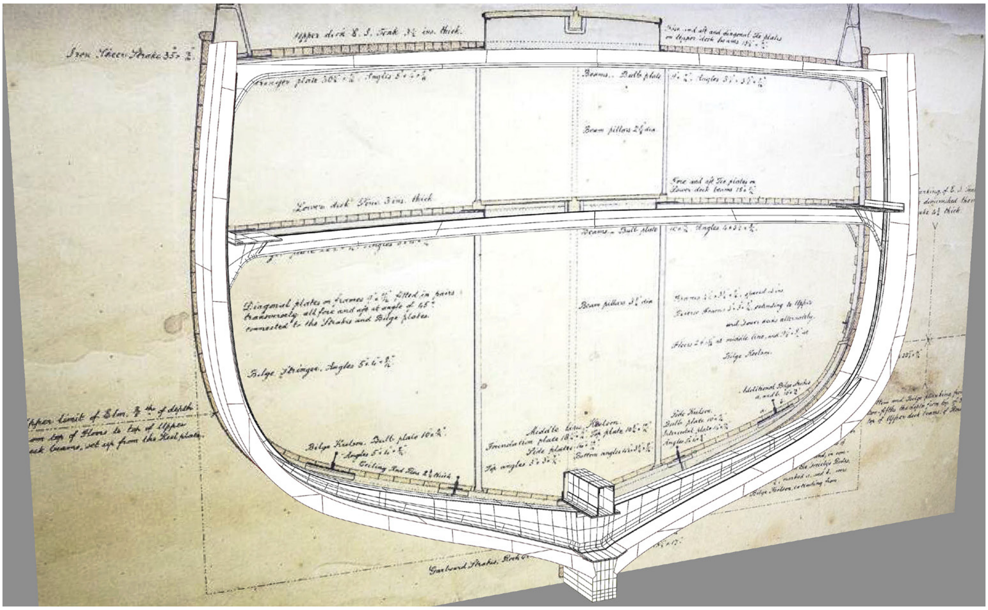

Fig 8.10. Centerframe of *Cutty Sark 2*
Source: *Cutty Sark 2* Sail Foudation

The planning and the construction of the ship would be made through composite construction — meaning the frames, the skeleton of the ship is made of steel, and be made first, and then the planking would be made from wood; this was a very efficient way of building a ship in the 19th century. It took only 11 months to build the original *Cutty Sark* 149 years ago. We hope that, with the aid of modern technologies, we will be able to build it within the same time limit; however, it will not be a problem if we are not able to accomplish this. There will be a demand for experienced woodworkers to make the wooden planking while also having the possibility to use modern technology in the creation of the steel structure. Our vision is the following: we produce the steel frames at the professional shipyard and then transport the vessel's skeleton to the construction site and assemble it. This will form the base for our idea of shipyard-museum; in other words, we would turn the shipbuilding process into a live, everchanging exhibition, open to the public, so that they may have the opportunity of viewing the craftsmen plying their trade and learning how ships were built in the past. Hence, the shipyard would also serve as a cultural space for local communities (and especially to the younger generations) and as a tourist attraction.

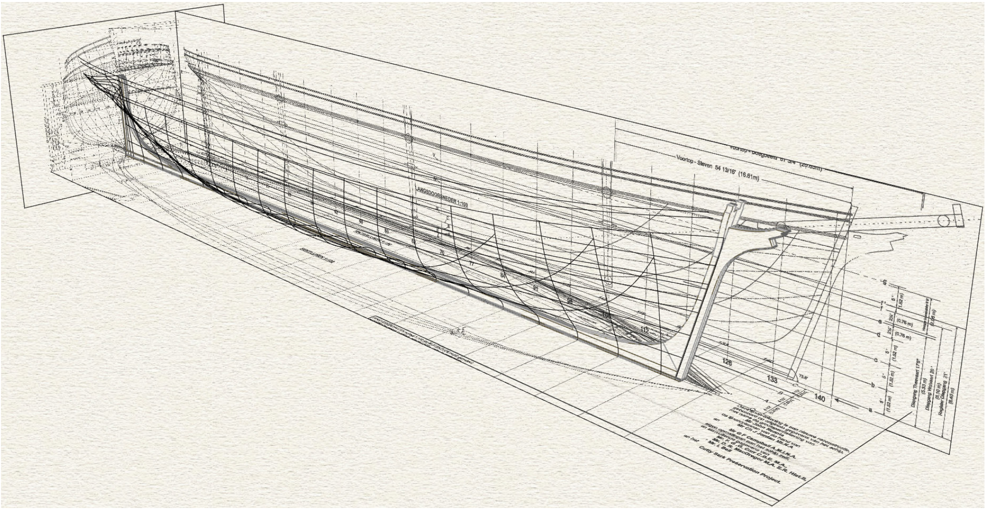

Fig 8.11. Drawings of *Cutty Sark 2*
Source: *Cutty Sark 2* Sail Foundation

A 3D model with all the steel structures and ship's equipment allocation is ready. We intend to have the vessel's interior design as historically accurate as possible: cabins and furniture that are faithful, detailed reproductions of those in use during the 1800s, so guests would feel as if they have just stepped into a time machine. A limited number of passengers would have a chance to join the crew in the travels, having the 19th century replica cabins as living quarters. The ship's crew would have access to modern-looking accommodations, which would enable them to relax and rest between watches in comfortable quarters.

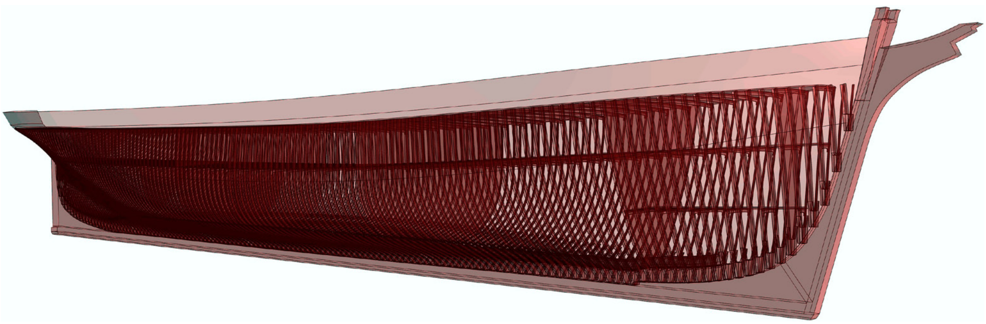

Fig 8.12. 3D drawings of *Cutty Sark 2*
Source: *Cutty Sark 2* Sail Foundation

The entire tweendeck would serve as the trainees' living space. It would be furbished with 50 hammocks, with the addition of, perhaps, canvas walls, to offer them some modicum of «personal space». While docked in a port, these walls would be dismantled, converting the vessel's deck into a large single space, suitable for receptions, dinners, promotional events for companies etc. This would be a venue big enough for corporate events, exhibitions and similar events wherever the ship went.

If we are successful, we will construct in the future other replicas of famous clippers (the *Thermopylae* comes, first and foremost, to mind; this ship was *Cutty Sark*'s opponent in the «tea race». The «Ambassador», which is now being restored in Chile, is also a candidate worth considering), all to be built in the same shipyard.

Fig 8.13. Design layout of *Cutty Sark 2*
Source: *Cutty Sark 2* Sail Foundation

We have still a long way to go but we already possess detailed historical information, a solid background and extensive experience, an extremely well-motivated team of volunteers and the potential interest from environmentally conscious organizations on a European and global level.

Now we only have to secure the support on the local level to finally decide where the ship will be constructed.

EDITORS' BIOGRAPHIES

Amélia Polónia

Amélia Polónia is a Professor at the Department of History, Political and International Studies of the Faculty of Arts of the University of Porto and scientific coordinator of the CITCEM Research Centre. Her scientific interests include agent-based analysis applied to historical dynamics, social and economic networks and seaport communities. These topics are applied to her direct interests on the Portuguese Overseas Expansion and the European Colonization in the Early Modern Age. Seaports history, migrations, transfers and flows between different continents and oceans as well as the environmental impacts of the European colonization overseas are key-subjects of Amélia Polónia's recent research.

Francisco Contente Domingues

Francisco Contente Domingues (Lisbon, 1959) is Full Professor of History of Portuguese and European Expansion and director of post-graduate studies in Maritime History at the Department of History of the University of Lisbon, and member of the Centre of History of the same University.

He authored about ten books and more than one hundred book chapters and articles mostly on the History of Navigation in 15th to 17th centuries. He is the Editor of the reference book *Dicionário da Expansão Portuguesa*, 2 vols., 2016 [*Dictionary of Portuguese Discoveries*], and a member of the Naval Academy (*emeritus*), Academy of Sciences and Academy of History.

AUTHORS' BIOGRAPHIES

António José Carmo

Designer in charge of the tech department of the shipyard Samuel e Filhos Lda., from 1981 to 2006 and partner-manager between 1996 and 2006.

Responsible for over 70 projects of wooden ships, 7 in aluminium and 2 in steel for inshore fishing. Author of 4 projects of wooden ships, awarded with the prize for innovation by the Naval Engineering Tech Days — 1990.

Member of the research team of the vessel found at the Belinho beach — Esposende, by invitation of *For Sea Discovery*, in August of 2015.

Author of a Glossary of terms used by Vila do Conde's shipyards, part of the classification process of the «Techniques of wooden shipbuilding and repair of Vila do Conde» at the National Inventory of Intangible Cultural Heritage.

David Plouviez

David Plouviez is a lecturer in Modern History at the University of Nantes, a member of the Centre for Research in International and Atlantic History (CRHIA EA 1163). His research focusses on the economics of naval warfare in Europe from the 17th century to the 19th century, in which he analyses the conditions for the construction of major navies, as well as technical transfers in the fields of shipbuilding and sea artillery during the same periods (*La Marine Française et ses réseaux économiques au XVIII^e^ siècle*, Paris, Les Indes savantes, 2014; *Les Corsaires nantais pendant la Révolution*, Rennes: PUR, 2016). In recent years, his work has specifically focussed on restoring working conditions in shipyards while trying to establish technical exchanges between Navy engineers and dockers, while at the same time drawing the outlines of the mobility of all these men.

Eric Rieth

Eric Rieth was born in Algeria. He studied medieval archaeology and maritime history at the Sorbonne University of Paris. The subject of his Ph. D. submitted in 1978 to the Sorbonne University was the archaeology of the "flat bottom-based" shipbuilding tradition in north-west Europe from Ancient to Modern times. As nautical archaeologist and professional diver, he has directed excavation of wrecks at sea (Mediterranean, Atlantic, Channel), rivers and lakes since 1971. His speciality is inland and seagoing boat and ship archaeology. He has also a great interest in the ethnographical evidences as sources of comparison and interpretation of archaeological data. He is now Emeritus Director of Research at the National Centre of Scientific Research (CNRS). He teaches nautical archaeology at the Sorbonne University (Paris 1). He is chief of the Nautical archaeology department of the National Maritime Museum, Paris. His last book published is *Navires et construction navale au Moyen Age*, Editions Picard, Paris, 2016, 352 pages.

Filipe Castro

Filipe Vieira de Castro is Professor of Anthropology at Texas A&M University, holds the Frederick R. Mayer II Fellowship of Nautical Archaeology, and is the Director of the J. Richard Steffy Ship Reconstruction Laboratory. He has a degree in civil engineering from Instituto Superior Técnico, a Master of Business Administration from the Catholic University of Lisbon, and a PhD in Anthropology from Texas A&M University.

Francisco J. S. Alves

Born in Lisbon in 1942.
CMAS diver, Lisbon (1959) and in Antibes, France (1974).
Maîtrise Histoire — Sorbonne (1975).
Disciplinary equivalences of DEA of Doctorat de 3.ème Cycle — Institut d'Art et d'Archéologie — Université de Paris 1 — Sorbonne (1976).
Director of the rescue excavations of *Bracara Augusta* (Braga) and President of the Unidade de Arqueologia of the Universidade do Minho (Braga) (1976/1977-1980).
Director of the Museu Nacional de Arqueologia (MNA) (Belém, Lisbon, Portugal) (1980-1996).
Director of the Centro Nacional de Arqueologia Náutica e Subaquática (CNANS) of the Instituto Português de Arqueologia (IPA((1997-2007), and organiser of the International Symposium on Archaeology of Medieval and Modern Ships of Iberian-Atlantic Tradition (Lisbon, 1998) as promoter, coordinator, speaker, and editor of the respective Proceedings (2001).
Invited Professor of Nautical and Underwater Archaeology of the Faculdade de Ciências Sociais e Humanas of the Universidade Nova de Lisboa (FCSH-UNL) (2003-2012).
Retired in 2012 due to age limit.
Associated research member of the Instituto de Arqueologia e Paleociências (IAP) of the Faculdade de Ciências Sociais e Humanas da Universidade Nova de Lisboa (FCSH-UNL).

María Amparo López Arandia

María Amparo López Arandia is currently Assistant Professor of Early Modern History of the History Department at University of Extremadura (Spain).
Her research works have especially payed attention to the Religious History in the 16th and 17th centuries, studying different aspects: the spiritual trends which appeared in the Renaissance, or the action of the religious orders and their influence on politics in regional areas — especially in

Andalusia — but also in the European estates, from some courtly jobs like the royal confessors. At this moment, she is working about some special administrative territories too, as the Spanish maritime provinces in the 18th century, especially about the case study of the maritime province of Segura de la Sierra. She has coordinated a research project about this subject, financed by the Instituto de Estudios Giennenses (Diputación Provincial de Jaén) between december 2016 and october 2017.
She is a member of two international research *Networks in Early Modern History: the Cibeles Network*, based on Urban History, and the *Columnaria Network*, focused on the Iberian Monarchies in the Early Modern Age.

Richard W. Unger
Richard W. Unger is professor emeritus of history at the University of British Columbia. Trained as an economic historian, he has published extensively on shipbuilding and shipping in medieval and early modern Europe. He has written on the brewing industry in the same period as well as on Dutch brewing from the Middle Ages to the end of the nineteenth century. More recently he is the author a book on cartography in the Renaissance as well as co-author of a short outline of energy consumption in Canada in the last two centuries. He is now working on patterns of energy use in the late Middle Ages. He is the former president of the Medieval Academy of America.

Vladimir Martus
Vladimir Martus started his sailing career in 1980. He has raced for his country's National Sailing Team for 12 years. He is Yachtmaster Instructor (RYA).
Graduated from the St. Petersburg University of shipbuilding as a naval architect in 1990. As naval architect and master-builder, he has built two large wooden replica sailing ships: Schooner *St Peter* (80 feet, 1991) and frigate *Shtandart* (110 feet, 1999). As captain of the Shtandart, he has taken part in Tall Ship Races since 2001.
Vladimir was involved and has directed several large maritime events and festivals in St. Petersburg. He is president of the non-profit sail-training organization "Shtandart Project" and project director of the "Cutty Sark 2 Sail Foundation".

Marine Jaouen
Marine Jaouen, graduated in naval archaeology from the modern period at the University of Paris I Panthéon-Sorbonne.
Hired in 2006 as technician at the Drassm (French Ministry of Culture), in charge of the National Archaeological Map of the littoral Zone; manages excavations in modern period.

Olivia Hulot
Olivia Hulot, graduated in naval archeology from the modern period at the University of Paris I Panthéon-Sorbonne.
Hired in 2008 as an engineer at the Drassm (French Ministry of Culture), she is in charge of management of maritime littoral cultural heritage for the Brittany and Loire-Atlantique.
Since 2014, she manages a specific research program to study wrecks buried on intertidal zones.

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EDITORS
AMÉLIA POLÓNIA
FRANCISCO CONTENTE DOMINGUES

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