Ana Crespo Solana
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Nigel Nayling *Editors*

Heritage and the Sea

Volume 1: Maritime History and Archaeology of the Global Iberian World (15th-18th centuries)

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Editors
Ana Crespo Solana
Instituto de Historia, CSIC
Spanish National Research Council
Madrid, Spain

Filipe Castro
História, Territórios e Comunidades
Center for Functional Ecology
Lisboa, Portugal

Nigel Nayling
Institute of Education and Humanities
University of Wales Trinity Saint David
Lampeter, Ceredigion, UK

ISBN 978-3-030-86459-0 ISBN 978-3-030-86460-6 (eBook)
https://doi.org/10.1007/978-3-030-86460-6

This Springer imprint is published by the registered company Springer Nature Switzerland AG
The registered company address is: Gewerbestrasse 11, 6330 Cham, Switzerland

Preface

At the core of this collection of papers from a diverse range of authors is a desire to draw on a wide array of perspectives and disciplinary approaches to renew our understanding and appreciation of Iberian maritime heritage of the Early Modern Period. Its catalyst is the ForSEAdiscovery Project—a multi-disciplinary endeavour which brought together established and emerging researchers to investigate Iberian shipbuilding and particularly its relationship to forests and timber supply through the lenses of archaeology, history and earth sciences. Many of the papers draw directly on the project's research results. Other contributions come from collaborations and research associations beyond and encouraged by ForSEAdiscovery.

Our hope is that this collection will be of interest to scientists, academics and students of history and archaeology in the broadest sense, but also accessible to a broad audience seeking a current overview of research into the phenomenon of Iberian seafaring during a period of technological and social transformation, a period in which European horizons expanded to encompass global dimensions through maritime enterprise. Our ambition has been to seek and present new insights and research directions particularly through multi-disciplinary collaboration.

We owe a debt of gratitude to a wider research community than solely the contributors to this collection. To our ForSEAdiscovery family: Aoife Daly, Ute Sass-Klaassen, Jan Willem Veluwenkamp, Ignacio García González, Tomasz Wazny, Garry Momber, Christin Heamagi, Brandon Mason, and so many other members of the ForSEAdiscovery consortium, colleagues and friends who accompanied us in this incessant search for answers in the forest and in the sea of the history of the Iberian empires.

We dedicate this book to our beloved Fadi, lost to us too young, always in our hearts.

Madrid, Spain — Ana Crespo Solana
Lisboa, Portugal — Filipe Castro
Lampeter, UK — Nigel Nayling

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The original version of this book was revised. The correction is available at https://doi.org/10.1007/978-3-030-86460-6_14

Contributors

Filipe Castro Universidade Nova de Lisboa (UNLA), Lisbon, Portugal

Arnaud Cazenave de la Roche Instituto de Historia, Consejo Superior de Investigaciones Científicas (CSIC), Madrid, Spain

Fabrizio Ciacchella Laboratorio di Historia Maritima e Navale (NavLAB), University of Genova, Genova, Italy

Ana Crespo Solana Instituto de Historia, Consejo Superior de Investigaciones Científicas (CSIC), Madrid, Spain

María José García-Rodríguez Instituto Geográfico Nacional (IGN), Madrid, Spain

Marijo Gauthier-Bérubé Texas A&M University (TAMU), College Station, USA

Cayetano Hormaechea Asociacio d'Amics del Museo Maritim de Barcelona (AAMMB), Barcelona, Spain

Germán Jiménez- Montes University of Groningen, Groningen, The Netherlands

Roberto Junco Sánchez Instituto Nacional de Antropología e Historia (INAH), Mexico City, Mexico

Miguel Martins Universidade Nova de Lisboa (UNLA), Lisbon, Portugal

Nigel Nayling University of Wales Trinity Saint David (UWTSD), Lampeter, UK

José Virgílio Pissarra Universidade Nova de Lisboa (UNLA), Lisbon, Portugal

Marcel Pujol i Hamelink Escola Superior de Conservació i Restauració de Béns Culturals de Catalunya, Barcelona, Spain

Patricia Schwindinger Texas A & M University (TAMU), College Station, TX, USA

Koldo Trápaga Monchet Universidad Rey Juan Carlos, Madrid, Spain

Chapter 1
Remains of the Shipwreck: An Introduction to the Iberian Maritime and Underwater Landscape

Ana Crespo Solana and Filipe Castro

Abstract The demand for wood in the sixteenth and seventeenth centuries forced the adoption of sustainable policies and practices in forestry in the Iberian Peninsula, as deforestation and increased dependence on imported timber threatened Spanish and Portuguese interests overseas. Little by little, policies for the conservation and organization of resources were developed that reached a significant peak in the eighteenth century, at least in the Spanish case (Nayling and Crespo Solana 2016; Crespo Solana et al. 2018; Crespo Solana 2019). The sixteenth century was also a century of innovation in art, science, and technology, and this technological advance was partly the result of the socio-technological exchange between Mediterranean and northern European cultural traditions epitomized by developments in ship design and construction. In the twentieth century, ships and boats were the protagonists of important and more recent studies that have been of great influence in the development of a more integrated study of the ships and the populations that built, sailed, and lost them. These studies helped the development of an archaeological record (Castro et al. 2018) related to intertidal zones and submerged sites, focusing on the analysis of the transfer of knowledge about ocean navigation, especially between the Mediterranean and the Atlantic (Borrero et al. 2021).

The demand for wood in the sixteenth and seventeenth centuries forced the adoption of sustainable policies and practices in forestry in the Iberian Peninsula, as deforestation and increased dependence on imported timber threatened Spanish and

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A. Crespo Solana (✉)
Instituto de Historia, Consejo Superior de Investigaciones Científicas (CSIC), Madrid, Spain
e-mail: ana.crespo@cchs.csic.es

F. Castro
Universidade Nova de Lisboa (UNLA), Lisbon, Portugal
e-mail: fcastro@fcsh.unl.pt

A. Crespo Solana et al. (eds.), *Heritage and the Sea*,
https://doi.org/10.1007/978-3-030-86460-6_1

Portuguese interests overseas. Little by little, policies for the conservation and organization of resources were developed that reached a significant peak in the eighteenth century, at least in the Spanish case (Nayling and Crespo Solana 2016; Crespo Solana et al. 2018; Crespo Solana 2019).[1] The sixteenth century was also a century of innovation in art, science, and technology, and this technological advance was partly the result of the socio-technological exchange between Mediterranean and northern European cultural traditions epitomized by developments in ship design and construction. In the twentieth century, ships and boats were the protagonists of important and more recent studies that have been of great influence in the development of a more integrated study of the ships and the populations that built, sailed, and lost them. These studies helped the development of an archaeological record (Castro et al. 2018) related to intertidal zones and submerged sites, focusing on the analysis of the transfer of knowledge about ocean navigation, especially between the Mediterranean and the Atlantic (Borrero et al. 2021).

The ForSEAdiscovery project intertwined history, underwater archaeology, and wood science with applications of Geographic Information Sciences (GIS) to produce data integration, mapping, and visualization tools (Crespo Solana 2014). As part of this multidisciplinary project, studies of the historical evidence for timber exploitation, selection and supply, contemporary forestry practice and preservation, were complemented by archaeological excavation and investigation of early modern Iberian shipwrecks and the application of dendrochronology to these assemblages. Dendrochronology has developed as an essential tool for the precise dating and provenancing of timbers found in archaeological ship finds but only in areas where well-replicated reference tree-ring chronologies have been constructed (Nayling 2008; Rich et al. 2018). This has limited its use in the Iberian Peninsula where historical dendrochronology has had less application than in the rest of Northern Europe (Domínguez-Delmás et al. 2015). The ForSEAdiscovery project sought not only to build on extant historical tree-ring chronologies in areas known to have supplied timber for shipbuilding, but also to explore additional methods in wood science which might complement provenance based on tree-ring widths alone.

This collection of essays brings together various research projects related to Iberian ships and the world in which they were built and sailed. It features a collection of works carried out by a network of experts in the fields of history, archaeology, anthropology, and associated disciplines. The result summarizes a body of work that we had not planned to achieve, but that was developed beyond and above the goals we had set up and achieved for the Marie Curie Multi-ITN project (agreement no.: 607545) entitled *Forest resources and Ships for Iberian Empires: ecology and globalization in the Age of Discovery,* ForSEAdiscovery, with Ana Crespo Solana and Nigel Nayling principal investigators (Nayling and Crespo Solana 2016). We had not anticipated how well we worked together, the synergies

[1] *Forest Resources for Iberian Empires: Ecology and Globalization in the Age of Discovery (16th–18th centuries)*. ForSEAdiscovery (grant agreement no. PITN-GA-2013-607,545), funded by the Marie Sklodowska Curie Actions, Initial Training Networks, European Commission (ITN). https://digital.csic.es/handle/10261/173130.

we created, and the sense of community we developed. As it stands, this book is a summary of what we learned about these incredible machines—oceangoing ships—and the people who built and sail them. In this sense, it is intended as a set of incremental contributions to our knowledge, and not as a treatise on Iberian navigation in the early modern age, which would require a much more extensive work, and would probably be useless in one decade or so.

In the fifteenth century a new and large enterprise spread over the oceans, creating new theatres for exchange, and generating a new globalized interculturality that profoundly affected European culture. New maritime routes were opened in all directions, as new resources were sought to meet the demands that this historical process produced. The exploitation of natural resources, especially wood, is at the origins of the mercantile capitalism of classical modernity. The use and exploitation of timber resources was determined by both the traditional demand of materials for the shipbuilding industry and the new experimental needs of the developing shipbuilding technologies. Ships became the most important instruments of this globalization and extraordinary inhabited machines (Castro 2008). The wrecks of ships built in the Iberian Peninsula and in the Americas during expansion of Iberian Empires (sixteenth-eighteenth centuries) are iconic examples of underwater cultural heritage where multiple modern sovereign states and their citizens hold interests. All too frequently, these shipwrecks have been commercially exploited leading to the degradation and destruction of internationally important heritage. The sixteenth century has perhaps attracted more attention from the public because its shipwrecks fuelled a treasure hunting industry that has inspired many to seek and destroy the archaeological remains of most of these ships. These shipwrecks have attracted some scholarly attention as well, and Thomas Oertling was the first to propose a set of architectural signatures characterizing the ships of the Iberian Peninsula, with his seminal paper "The concept of the Atlantic vessel" (Oertling 2001), which highlighted the construction of the Iberian ship as a paradigm. However, Iberian ships are still a largely unknown collection of ship types that cruised the oceans to and from the Iberian Peninsula from the fifteenth to the eighteenth centuries (Castro 2008).

ForSEAdiscovery is the first project funded by the Marie Curie program of the European Union aimed at an interdisciplinary study on modern history and maritime archaeology. Its objectives were based on a trans and interdisciplinary methodological and theoretical perspective to investigate the supply of wood for shipbuilding in the Iberian empires between 1500 and 1800. The origin and reason for the project revolves around thousands of fragmented stories shipwrecks and the problem of the scarce nautical and underwater archaeology that makes a historiographical revision necessary as well as to explain the reasons for this interdisciplinary history. The prevailing historical context forms a time-space framework of undoubted transcendence due to the wide commercial and financial networks related to the lucrative business of wood (the oil of the first global age), the master carpenters, delegates and servants of the crown, seafarers, suppliers, and many other agents whose empirical presence becomes a reality both in the documentary sources collected in archives and in the remains of archaeological evidence found in wrecks. The naval history and narrative history behind the shipwrecks has hardly interested those who have intervened in archaeological sites. Unfortunately, most of the attention of his existence was on treasure hunters.

Studies have highlighted the focus of route logistics, the reason for the evolutionary perfection of shipbuilding techniques. The ForSEAdiscovery project has also drawn attention to the relationship between the maritime empire and capitalism and the plundering of natural resources, especially wood. The historical investigation allows us to know how the routes, places of origin, and networks of agents involved in the transport and use of wood were organized, from the forest to the shipyards (Varela Gomes and Trapaga Monchet 2017). There is already knowledge about this, especially regarding the transport of wood from North and East Europe to the Iberian Peninsula between the sixteenth and eighteenth centuries. Much is known about these networks, but little is still known about the timber monopolies that constituted true global trade. We have organized this book into 26 chapters, organized along three main lines of research: history, dendrochronology, and archaeology.

Chapter 2 introduces the ForSEAdiscovery Marie Curie research project and explains the main goals of our multidisciplinary research. A special emphasis is placed on explaining in depth the meaning and scope of the project, which was a look into the importance of timber the basic source of energy and construction materials behind the European driven globalization of the early modern period. This project entailed a holistic approach and the coordination of a wide team of experts from both the hard sciences and the humanities. This interdisciplinary teamwork focused on the maritime cultural heritage, its historical significance, and its methodological and transdisciplinary relevance in relation with environmental sciences, necessary to understand the natural and patrimonial dimensions of the historical processes. In Chap. 3 author Ana Crespo Solana introduces the people and the networks of commerce of the Spanish *Carrera de Indias*. This chapter presents a short overview of the connections between ships, merchants, cargoes, harbours, and routes, and emphasizes the cosmopolitan nature of the intertwined interests of the merchants and the political power. Chapters 4, 5, and 6 discuss the shipbuilding traditions that flourished in the Iberian Peninsula during the late middle age and the early modern period. Chapter 4, by Filipe Castro, Marijo Gauthier-Bérubé, and Miguel Martins, is a short summary of what characterizes the ships of the Iberian Peninsula in this period. It presents the generally accepted sources for the Peninsula's shipbuilding tradition – Mediterranean and North European – and details the evidence behind these assumptions. Chapter 5, by Filipe Castro and José Virgilio Pissarra, presents a summary of the characteristics that characterize the most commonly mentioned ship types, with a special emphasis on caravels and galleons. Chapter 6, authored by Marcel Pujol y Hamelink, is a detailed history of the Medieval origins of Spanish shipbuilding.

Chapter 7 is authored by specialists Arnaud Cazenave de la Roche, Fabrizio Ciacchella, Cayetano Hormaechea deals with an important late sixteenth century Ragusan scholar, Nicolò Sagri, or Nikola Sagroević, who wrote several texts on navigation and shipbuilding. The manuscript presented in this chapter is titled *"Il Carteggiatore"*, and includes an important section that offers an overview of Italian-influenced shipbuilding of the early modern period through the example of a typical merchant ship of that time, a nave, the method of calculating its tonnage, the making of sails and anchors. Chapters 8 and 9 address some of the problems of supply and demand of timber for shipbuilding. Chapter 8, by Germán Jiménez Montes, presents an interesting overview on the north European timber trading networks, and associated trades, related to naval provisions in Seville. Jiménez Montes details the development of the Seville shipyards and the key role that the Low Countries, as well as Dutch, Flemish, and German agents, played in the trade between the Baltic and the Iberian Peninsula. Chapter 9, authored by historian Koldo Trapaga Monchet, presents a new and important overview of the provisioning of Portugal shipyards during the reign of king Philip IV (1621–1634). This chapter is an excellent and thorough account of this important period and its technological and logistical changes related to the shipbuilding industry.

Chapters 10, 11, and 12 analyse documents and vocabulary related to shipbuilding in the dawn of the early modern age. In Chap. 10 Ana Crespo Solana presents an interdisciplinary approach to the study of shipbuilding in Modern Spain, combining archaeology and history as complementary sources for a better understanding of both the socio-institutional framework of fleets and navies and to the technical characteristics of shipbuilding architecture. Chapter 11, authors present a summary of current knowledge on technical texts on shipbuilding. As these are rare before the Renaissance, the story of the evolution of watercraft in Europe in the two millennia before the appearance of the first shipbuilding treatises is regional and complex. It is not until the fifteenth century that the first technical texts describe the large European merchantmen, which start converging into a small number of types, sharing the same characteristics because they were designed and built for similar functions. Following up on the technical subject, Roberto Junco introduces and presents an early eighteenth-century manuscript in Chap. 12, written by a monk named Joseph de Ledesma after a voyage from Mexico to Rome. One of the earliest known maritime glossaries in Spanish, its importance is thoroughly explained in the author's introduction.

Chapter 13 details a GIS application on sixteenths to eighteenth century shipwrecks. The authors present a georeferenced database framed within the context of the project ForSEAdiscovery. The general objective of this database is to cross-link historical information with dendro-archaeological evidence in order to date and provenance the wood used in Iberian shipbuilding, and to provide a large amount of shared data through GIS-oriented databases that further analyses. The authors emphasize the importance of special analysis for an historical understanding of the definition of the Iberian ship characteristics and their evolution. In Volume 2, Chap. 1, Marta Domínguez Delmás, Sara Rich, and Nigel Nayling present a summary of the advances in dendrochronology in the Iberian Peninsula, during the last decade, and detail the challenges and strategies selected to develop this discipline. In Vol. 2, Chap. 2 the author, Sarah Rich, ventures into theory and proposes a philosophical approach to the study of shipwrecks, "object-oriented ontology, to the study of ships and shipwrecks in order to address commonly encountered, and overlapping, issues of mereology, identity, origins, and representation". Volume 2, Chap. 3, by Miguel San Claudio, the director of the archaeological excavation of the Ribadeo shipwreck, a warship named *Santiago de Galicia* that ended its days in 1597, at the mouth of the Eo River. San Claudio describes how the particular geographical position of Galicia, on the extreme west of Europe, made its coasts part of a number of important maritime routes and a theatre of operations during the religious wars that ravaged Europe during the sixteenth and seventeenth centuries. Two important shipwrecks lye on the coast of Galicia, namely San Jerónimo and Santiago de Galicia, both warships, galleons, which are providing the scholars with unique information about the life aboard the huge Spanish war galleons of this period.

Chapter 4 signed by Beñat Eguiluz Miranda, Marta Domínguez-Delmás, Koldo Trápaga Monchet, Miguel San Claudio, and José Luis Gasch-Tomás, is a study of the Ribadeo 1 shipwreck, or *Santiago de Galicia* (c. 1597), and the results of the 2015 archaeological survey work, and the new historical research that was conducted in Spanish archives to search for documents referring to the wreckage. The results of this multidisciplinary research led to the tentative identification of this shipwreck as *Santiago de Galicia*, a galleon built in Castellamare di Stabia, near to Naples, Italy, in the late 1580s or early 1590s, and sunk in Ribadeo in AD 1597. Volume 2 Chap. 5 is authored by Ana Almeida, Tânia Casimiro, Filipe Castro, Miguel Martins, Alexandre Monteiro, and Rosa Varela Gomes, and presents a summary of the Belinho 1 Shipwreck project. The ship was found in the winter of 2014 and exposed between 2015 and 2017 by a succession of storms which pushed timbers and artifacts ashore. All timbers and artifacts were recovered, conserved, and curated by the archaeologists of the Esposende municipality. This chapter describes the present state of the research on this shipwreck and the collaboration between a large and diverse community of domain experts and the participating public. In Vol. 2 Chap. 6, Milagros Alzaga García, Lourdes Márquez Carmona, Mercedes Gallardo Abárzuza, Nuria Rodríguez Mariscal, Josefa Martí Solano, Aurora Higueras-Milena Castellano, José Manuel Higueras-Milena Castellano, from the Underwater Archaeology Centre (CAS) of the Institute of Historical Heritage of Andalusia (IAPH), created in 1997 to investigate the Underwater Archaeological and Maritime Cultural Heritage of the Andalusian autonomous community. This chapter presents two shipwreck sites of Iberian tradition in the Bay of Cadiz, Andalucía – the San Sebastian and the Delta I shipwrecks—and analyses the date through documentary and archaeological sources. Volume 2 Chap. 7, by Nick Budsberg, Charles Bending, Nigel Nayling, and Filipe Castro, is a case study in field archaeology: The Highbourne Cay Shipwreck, an early sixteenth-century Spanish ship lost in the Bahamas. The authors revisit this shipwreck, which was looted and partially destroyed by treasure hunters in the 1960s, surveyed and partially excavated in the 1980s, and revisited by the ForSEAdiscovery team in 2010s.

Volume 2, Chap. 8 is an overview of the state of maritime archaeology in the Dominican Republic. The author, Carlos Leon Amores, presents a history of the policies for the submerged cultural heritage and the impact of treasure hunting on the country's cultural heritage, and describes a set of important case studies of ships found around the coast. Volume 2, Chap. 9 is authored by Ana Rita Trindade, Marta Domínguez-Delmás, Mohamed Traoré, Nathan Gallagher, Sara Rich, and Adolfo Miguel Martins. It is an analysis of the timbers of the eighteenth-century frigate *Santa Maria Magdalena*, one of the case studies developed within the ForSEAdiscovery project. This interdisciplinary approach combined history, archaeology, and wood science to identify and characterize this ship. In Chap. 10 José Luis Gasch-Tomás presents an overview of the so-called Manila galleons, which crossed the Pacific Ocean from 1565 to 1815 in a commercial route between Mexico and the Philippines that connected the two worlds and facilitated the exchange of goods, persons, and ideas between the two continents. Chapter 11, by Pablo Ortega del Cerro, is an overview of the maritime routes and the knowhow necessary to ensure a steady and safe flow of ships, cargos and people throughout the Spanish world. This chapter details the Spanish Navy effort to produce and disseminate geographical and hydrographical knowledge, develop new maritime routes, and improve shipbuilding techniques in the second half of the eighteenth century.

Chapter 12 is authored by Gregory Votruba and explains the technological development on the production of iron anchors from the second-millennium AD to the Age of Exploration. It is a thorough study of the construction changes faced by anchor makers from baton-assembled or laminated-beam anchors to lone-bar and then bundled-bars construction process. The author emphasizes the harness of waterpower as a determinant factor for the increase in size and weight of anchor-frames. Chapter 13, authored by world specialist Javier Lopez Martín, presents the study of the different types of cannon used during the first decades of the sixteenth century, and describes the reforms implemented on ships to increase the number and size of cannons carried. Lopez Martín explains the armament of merchantmen, the developments started in the Mediterranean, the introduction of gunports, and other aspects related to the protection of the valuable transatlantic cargoes.

This collection of papers ties a significant number of research strategies and developments pertaining to the study of the European seafaring history in the early modern period. It is intended as a holistic collection of looks and strategies and presents a kaleidoscopic approach to the study of a particular portion of the history of technology. The chronological scope of this book is quite wide, ranging from the late medieval period to the enlightenment. The wide range of research topics addressed results from the interdisciplinary nature of the ForSEAdiscovery project and beyond. As mentioned above, it was a look at shipbuilding, the technical and scientific knowledge necessary to conceive, build, and sail these great machines of the seas, and its influence on both forestry policies and the management of shipyards and docks.

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Chapter 2
A Paradigm of Inter and Multidisciplinary Research: The ForSEAdiscovery Project

Nigel Nayling and Ana Crespo Solana

Abstract The ForSEAdiscovery project, a Marie Curie Initial Training Network funded by the European Union, saw a multi-disciplinary group of experienced and developing young researchers collaborate on a wide-ranging project to address the question of how the expanding Iberian empires secured the forest resources required to supply their fleets of mercantile and military ships from the sixteenth to the eighteenth centuries. This project aimed for a consilience between historians, archaeologists, and earth scientists in furthering our study of the synergies of shipbuilding technologies; forestry practice and regulation; timber selection, trade and supply; and developing innovative approaches to examining our pasts through dendroarchaeology in its widest sense.

1 Introduction

> Arsenals have been widely using soft pine wood which can only be found in Northern countries. The quality of the pine wood from Navarra and Segura is second to none. The timber used for hinges (*roldanas*) and pulley wheels (*pernos*) all comes from America; black poplar trees from Spain are also widely used: oak can be found in Catalonia, Asturias, Biscaya and Santander; pine for masts and hull come from Burgos, Segura, Navarra and Seville, as well as holm and gall oak (*quejigos*) timber for ribs (*cuadernas*); beech wood

The original version of this chapter was revised. The correction to this chapter is available at https://doi.org/10.1007/978-3-030-86460-6_14

N. Nayling (✉)
University of Wales Trinity Saint David (UWTSD), Lampeter, UK
e-mail: n.nayling@uwtsd.ac.uk

A. Crespo Solana
Instituto de Historia, Consejo Superior de Investigaciones Científicas (CSIC), Madrid, Spain
e-mail: ana.crespo@cchs.csic.es

A. Crespo Solana et al. (eds.), *Heritage and the Sea*,
https://doi.org/10.1007/978-3-030-86460-6_2

(*hayedos*) comes from the Pyrenees and Asturias. Even if we regard these forests as depleted, your majesty's vast forests in America appear endless[1]

For centuries the knowledge of shipbuilding has been considered a science subject to the development of local industries. In fact, local tradition and regional studies have marked the historical and archaeological studies on naval architecture and the evolution of the modern ship. This report written in 1802 by the sailor and last viceroy of New Spain, Juan Ruiz de Apodaca, reflects, however, a global vision of the origin of the main resource used in shipbuilding: wood and its provenance was an experimental science marked by the geographical changes and the nature of a resource that consists of a flexible and resistant material with which the different types of trees generate their trunks, growing year after year through a system of concentric and circular layers (tree-rings). There are multiple types of wood, whose characteristics vary enormously. But in general terms, it is an extremely useful material for human beings, who have used it since ancient times. Wood is an abundant, renewable, inexpensive, and easy-to-work raw material that, processed in the correct way, can withstand the onslaught of time for many years, in addition to, when used in construction, it offers a feeling of warmth and ancestral protection, for which it is a fundamental element in almost all human industries (Adams 2018). In its structure, the wood has an outer and inner bark (or cambium), sapwood (*Albura*, in Spanish terms), its central part or nuclei and a pith. There are many types of woods depending on their properties and appearance. The master ship carpenters knew these circumstances and characteristics empirically, and they developed a science to use in order to develop the most precise architectural techniques and avoid the susceptibility of wood to any action by environmental elements. During the sixteenth to eighteenth centuries an empirical science on forests was developed in order to know the anatomy of trees, their organography, devices were invented to determine the resistance of wood to bending and traction, all in order to use the resources of the forest in the main driving force of the maritime empires: the ship and its architectural science.

2 Historical Background

The European voyages of discovery and the connected seaborne European expansion of the fifteenth and sixteenth centuries were overwhelmingly dominantly carried out by Spain and Portugal. Both kingdoms build their own intercontinental empires with settlements and colonies in Africa, Asia, and America. In the seventeenth century the Iberian powers encountered stiff competition by the Dutch, the English, and the French and in the eighteenth-century Great Britain gained imperial primacy and dominance of the seas. Nevertheless, Spain and Portugal retained their American and Asian colonies and maintained their maritime connections with them throughout the early modern period. Oceangoing ships were the only means of communication and transport

[1] Juan de Apodaca, Report. "Informe que Don Juan Ruiz de Apodaca, brigadier del Real Arsenal de la Carraca dio a la Junta del Departamento de Cádiz, como vocal de ella, sobre el surtimiento de efectos para los reales arsenales de S. M." 23 de abril de 1802. Imprenta Real de la Marina, Isla de León, 1806.

between the near and distant parts of the Iberian empires. To build and maintain these vessels Portugal and Spain needed large amounts of timber, predominantly oak (*Quercus* spp.) and pine (*Pinus* spp.) but also many other species that were used to make various parts of the ship, and that are mentioned in Apodaca's text. Nevertheless, the question where that timber had been produced has hardly been asked and even less researched. Also, historiography has neglected the study of the influence that the commercial, maritime, and colonial European expansion had in the use of forests resources. Up to date, a few relevant works exist that relate expansion and deforestation, but their coverage of the Early Modern Period focuses on the eighteenth century, leaving references to sixteenth and seventeenth century brief and shallow (Albion 1926; Perlin 1989; McNeill 2004; Warde 2006). Inedited written sources are still available in certain geographic areas which may shed light on these relationships, especially those documentary sources derived from the efforts carried out by the Superintendency of mountains and plantations (*Superintendencia de montes y plantíos*) dedicated to managing the forest masses for the Navy and the Marine Departments (*Departamentos de marina*), created in 1724 for the administration of the forests of the Iberian Peninsula divided by provinces (Martínez González 2015; Wing 2015).

Historical studies have provided some theories about shipbuilding in the Hispanic Monarchy, including the age of the Iberian Union between the two crowns of Portugal and Spain (1580–1640). But what does History say about it? And what kind of innovative perspective could be offered by an interdisciplinary project? History of shipbuilding in Spain has developed around specific topics around dockyards stories and naval policies with only a few mentions of the use of timber and how wood had an influence on naval construction stages. A quantitative analysis of the frequency of topics on Spanish Naval History show that only the 11% of research works have been made about ships and shipbuilding and the majority of studies focused on exploration and colonies, navigation, naval battles, and biographies. Nevertheless, there is some important research about shipyards with particular focus in the eighteenth century. In fact, the eighteenth century sees new policies implemented for the construction of shipyards and arsenals (Cádiz-La Carraca 1717; La Graña and Ferrol 1726; Cartagena in 1728) and the new maritime departments were organized in which all timber supplies for the navy was arranged (Casado Soto 1991; Valdez-Bubnov 2018; Valdéz-Bubnov 2019). In the second half of the seventeenth century shipyards were built in Gibraltar with the cooperation of the British merchant in Cádiz (Serrano Mangas 1992). Also relevant was the creation of shipyards in colonial America, where it seems that many vessels used in the Indies were built, especially in Havana and in Guayaquil (Laviana Cuetos 1984; Serrano Alvarez 2008). Also, Galician ports on the Cantabrian seaboard had long enjoyed a prosperous relationship with Andalusian partners around wood trade for naval purposes as well as for making kegs and barrels. From Ribadeo and Viveiro wood was regularly shipped to Seville and Cadiz throughout the seventeenth century. The skippers were not from Galicia, and Portuguese merchants were also involved, especially until 1615. After that year, ships from England, the United Provinces, Lübeck, Hamburg, and Rotterdam, were introducing timber in Spanish ports. Cantabrian ports and Galicia became the most important shipbuilding area of the sixteenth century, with the well-known dockyards of Guarnizo. The location of Guarnizo as particularly suitable for shipyard site appears to be closely linked to the figure of Cristóbal de Barros (Superintendente de Fábricas, Montes y Plantíos), Superintendent of Factories, Forestry, and Plantations on the coast of Cantabria, whom Philip II in 1581 commissioned a series of nine galleons for the defence of the Indies (Martínez González 2015).

Since the Middle Ages, merchants from Guipuzcoa, Alava, and Vizcaya developed profitable trading activities with the North of Europe and their shipbuilding industry grew accordingly. From this area trade with other areas in the Cantabrian seaboard and beyond also flourished at Ribadeo, Llanes, San Vicente, and other ports in the Santander province. Their trade networks reached the Galician ports and soon after Oporto and Lisbon in Portugal and an important route to Andalusia soon began from the Basque Provinces. Soon afterwards important trade networks reached Barcelona, Genoa, Sicily and Sardinia. Basque fleets carried Castilian wool, wine and other produce to Flanders- Bruges and Antwerp- and the ports that changed hands from the English to the French, such as Bayonne, Bordeaux, La Rochelle, Harfleur, and Rouen. The Hanseatic ports were reached soon afterwards. This trade was regulated by the Bilbao Municipal Ordinances.[2] In the sixteenth century almost all sea villages in Cantabria boasted a working shipyard although the most important were at Colindres and Guarnizo, in which the largest galleons at the time were built. As a result of Cristóbal de Barros being appointed by Philip II to revitalize naval construction in the Cantabrian yards, it was there where most of the royal armadas sent against England were built. The shipyard at Folgote, established in 1475, became a Royal Shipyard in 1618. It was thought to be well defended from enemy attacks as it was located at the bottom of Santoña Bay. However, as a result of being placed under attack by the French in 1639, activity dwindled and was transferred to Guarnizo like other Cantabrian shipyards. Apparently Guarnizo was the yard in which La Pinta was built, as well as many other vessels among the largest at the time. As for naval construction, it is worth highlighting the conservationist policy applied by Philip II, reflected in his Royal Ordinances, and later copied by the English. Such policy ensured the sustainability of the forestry resources to be used in shipbuilding, the vast forests in Northern Spain. When this policy was later abandoned in the eighteenth century, a rapid degradation of the Cantabrian forests took place, almost to the point of total depletion.

3 The ForSEAdiscovery Methodological Framework

In order to build a historical-archaeological narrative of the origin of wood in Hispanic shipbuilding, several theoretical meanings have been raised in the research work of the ForSEAdiscovery project. Various theories and hypothesis have produced important results, some of which are explained throughout these two

[2] Bilbao Municipal Ordinances, 1477–1520. Medieval documental sources from the Basque Country in a 1996 edition.

volumes. Firstly, studies of social and economic theory about the relation between forestry resources and the competition among maritime empires must be made within this perspective on network cooperation and competition for organizing political and economic behaviour around forest resources and in the so-called Environmental History (Crespo Solana 2019). The ForSEAdiscovery project has tried to take research on the matter a few steps further in order to answer some important questions related to understand the ecological history of the Iberian forests and to explain to what extent and how the Iberian powers succeeded in maintaining the size and quality of their fleets. Key questions to be addressed in this context are: could Iberian forest resources sustain this increasing demand for timber or was the wood imported from elsewhere? If so, how were the trade networks organized? Did a scarcity of raw materials encourage the technological changes which occurred in shipbuilding in the sixteenth century or were they a result of socio-technological exchange between Mediterranean and Atlantic shipbuilding traditions? Did demand for timber lead to sustainable changes in forestry practice in the Iberian Peninsula or deforestation and increased dependence on imported material? Where had the timber which was used for building the ships of the Iberian fleets been produced? The case of the "Iberian Timber" is related to the arsenals and cages built in maritime-port areas and their link with the forestry logistics of the Iberian Peninsula where forestry management and timber felling were carried out. In various historical stages, institutions for good governance and forest exploitation were created, such as the Superintendency of Forests, the Maritime Departments or other offices such as the "Real Negociado de Maderas de Segura" (a bureau specialized in management timber in Sierra de Segura in Spain).

An added value of the ForSEAdiscovery Project is that it has tried to relate the history of naval construction and the progress of the Atlantic maritime trade with deforestation and the value of timber resources, and to find out if all this had an impact on the shipbuilding between the sixteenth to the eighteenth centuries. A line of research also has been developed regarding the theoretical framework of the social, economic, and politico-administrative framework in which the collection, commerce, distribution, and utilization of the forest resources were carried out, but also about the purveyance of timber used in shipbuilding, and the merchant networks behind this trade, getting to know the policies on naval construction in the period and their impact on the distribution channels of the forest resources. The secular relationship between the forest and the appropriation of its resources by agents and political powers, the use of wood for shipbuilding affected forest regulations (Crespo Solana 2016; Varela Gomes and Trapaga Monchet 2017).

Perhaps one of the most obvious lines of research in this project has been to identify a methodological connection between the information offered in the historical sources and the archaeological evidence with chemical and laboratory methods in order to establish new knowledge for the study of the woods used in shipbuilding. As the document cited at the beginning of this chapter exemplifies, historical data offers a wealth of references and empirical data from which to start building an authentic catalogue of historical woods. Apodaca wrote a short but very illustrative report on the types of wood and their provenance that should be used for each part of a ship. This text is perhaps one of many discourses that were already present in the writers and navigators' documents from the sixteenth century, and in the debates of the "Juntas" (Boards) on shipbuilding that took place in Spain and Portugal's government at various times. This, and other unpublished documents on the latent existing concern about the origin of the wood was, in fact, a question of the first magnitude for the political administrations in Spain and Portugal from the very beginning of the overseas expansion. These discourses on the utilitarianism of wood were parallel to the learning of the oceanic experience of Spain and Portugal and served to create the design of the so-called Iberian ship, present in literature and maritime historiography and to which several chapters are dedicated in this book (Chaps. 4, 5, 6, 7, 8, 9, 10, 11, and 12).

Part of the timber employed in local shipyards and naval industries was extracted from Iberian forests but significant quantities of timber were imported (Reichert 2016; Gallagher 2016; Gasch-Tomás et al. 2017; Kumar 2018; Jiménez Montes 2020). Despite the repeated protectionist policies of the Spanish Crown for the ships to be "national" Spanish; that is, owned by Spaniards and built in the Iberian Peninsula with Iberian timber, the very historical evolution of the Hispanic Monarchy, ruled by the Flemish-German Habsburg dynasty and which, for a time also, ruled Portugal, made the navies and fleets always depend on the provision of foreign resources. Several factors (which are analysed) in the works present in this book, such as the consolidation of mercantile capitalism, supported by a continuous background of wars, especially wars at sea, and the formation of extensive commercial and financial networks that controlled production and transportation of timber, made the Spanish Crown always dependent on a large-scale global trade, and even dependent on its enemies, who brought the timber into Spanish ports with the collusion of local authorities and through intermediaries. Consequently, sea power, forestry, and international trade became inextricably linked. From the historical perspective we have carried out new historical research that enabled us to identify forest regions in the Iberian Peninsula from where timber has been extracted for shipbuilding (Varela Gomes and Trapaga Monchet 2017; Trápaga Monchet 2019a, b). In relation to wood provenance sciences, the knowledge of how the historical "montes de marina" was managed by the political institutions and local administration is crucial in order to create reference chronologies (with "living trees" and historic buildings) for dating and identifying the origin of timber. Some works carried out by members of the team have delved, precisely, into this interdisciplinary narrative on the history and evolution of the naval models of the Iberian empires in the context of maritime expansion, the politicization of forest resources, the global timber trade and its environmental causes and consequences from the sixteenth to eighteenth centuries. Some results refer to the relationship between forest administration and shipbuilding regulation. The characteristics of the original regions from which wood was extracted have also been established, not only from the "montes de marina" but some "Reales Sitios" (Royal Sites) have also been included, as well as other areas close to coastal maritime sites, mountains, and pastures, all in Andalusia and the Basque Country, important centres of shipbuilding, where various shipyards were located (Trindade 2015; Jiménez Montes 2016).

The various causes of forest exploitation in locations directly administered by the Crown, such as the so-called Soto de Roma (in Fuente Vaqueros, Granada), and in the regions of Asturias, Cantabria, Galicia, or large areas of Portugal have also been analysed. Data collected from these spatial studies allow us to know the strong pressure that both the Crown and the local noble and ecclesiastical elites had on the Iberian forests, as well as the commercial networks themselves, which tried to organize from very early on a reorganization of forest resources and regions that oversized the areas established by the later (and curiously late) regulations on the marine mountains and the creation of the Maritime Departments between 1726 and 1748.

4 Interdisciplinarity

The methodological framework of the ForSEAdiscovery project also implies an interdisciplinary training programme to increase the background and experience of researchers in interdisciplinary techniques. Research has produced reference datasets comprising historical, archaeological, and wood science data such as dated ring-width series (Crespo Solana et al. 2018; Rich et al. 2018; Domínguez-Delmás et al. 2019). Dendro-archaeology, as well as the techniques for the study of the origin of the wood, has been used to analyse the timber found in numerous suspected Iberian shipwrecks investigated as part of the suite of scientific activities of the project. This discipline allows dating of archaeologically recovered wood to determine the year in which the trees were felled, transported, and used in the construction of ships (Nayling 2008). This complements the historical knowledge of these wrecks and allows the validation of the information extracted from documentary sources, which is applied for the first time in the field of Spanish and Portuguese naval history. Related to this, it is important to know how the timber trade networks were organized from the production areas. The main problem raised in the project refers to the different origins of the wood located in wrecks and the large amount of information available in historical databases on how wood was transported from North and East Europe to the Iberian Peninsula between the sixteenth to eighteenth centuries, something that is undoubtedly related to the speculation that at the time itself was had on forest resources (see Vol. Chap. 1, 3, 4, 5, 7, and 9). Historical documents can link information with dendro-archaeological analysis. Their study certainly contributes very much to increasing our insight. The scope of these sources and the information they produce, however, are, as so often is the case, limited. Therefore, ForSEAdiscovery has explored a combination of three sets of additional methods to gain a better insight into the matter. This combination of methods involves archaeology, dendrochronology, and wood chemistry. It aims at determining the provenance of the timber of wrecks of relevant Iberian ships: where and when grew the trees that were processed into this timber? Archaeological research enables us to identify relevant wrecks and to take samples from their wooden parts. Dendrochronology and wood chemistry enable us to analyse these samples and possibly determine their provenances.

An inventory of the historical and geographical sources on wood supplies (sixteenth-eighteenth centuries) has been produced, which serves as the basis for knowledge about the sources of tree species, especially oak and pine and other woods most used for shipbuilding. This literature catalogue has been carried out in different archives in Spain, Portugal, and other European countries. In this way, we know a large part of the wood acquisition process, its selection, trade, and transport, as well as the management practices and specific laws enacted to sustain and protect forest resources. This research has been the subject of two doctoral theses within the project and 4 individual research works. The information has been enriched with the comparison, where appropriate, with databases, such as The Sound Toll Registers Online.[3] And they have also used the databases on historical and archaeological shipwrecks of the repositories The ShipLAB (TAMU A&M), DynCoopNetData Collection (or CrespoDatabase Atlantic Trade), which are currently: NADL (The Nautical Archeology Digital Library) and the DynCoopNet-ForSEAdiscovery interface and web viewer of the CSIC's GIS Laboratory. (Gallagher 2016; Kumar 2018; Trindade et al. 2020) (see Chap. 13 in this book).

The GIS model integrates and combines information from the different disciplines involved in the project (history, archaeology, the provenance of wood) to provide a tool for the study of the use of forest resources. The ForSEAdiscovery database not only integrates data from the aforementioned pre-existing databases (whose data have already been conveniently inserted) but has also been enriched with a large amount of data from various information sources related to historical (with historical data on each ship) and archaeological vessels (with data on excavated wrecks and archaeological information. In these wrecks we have proceeded to collect samples of structural wood in order to compare it with dendrochronological analyses of woods made in laboratories. These wood samples have been obtained in fieldwork with living trees and in historical buildings. These data are being processed to be entered in the GIS, although so far there are at least three databases interspersed with various ship and shipwreck mappings. The result of this GIS and ForSEAdiscovery database thus integrates information from three different disciplines, but strongly related in terms of data. The historical analysis also offers us an overview of what the process-model of wood provision in shipyards for shipbuilding was like. It must be taken into account, however, that this process varied throughout the three centuries studied.

5 Archaeological Research

A fundamental debate undertaken with the whole project team at the very beginning of the ForSEAdiscovery project considered what we might consider to be an Iberian ship. A number of definitions were forthcoming which helped to define the scope of

[3] http://www.soundtoll.nl/index.php/en/over-het-project/str-online.

the project with regard to which shipwrecks might be considered for multidisciplinary study. Definitions proposed included:

1. Iberian based on construction characteristics. Whilst Oertling (2001, 2004) and others have attempted to define a series of traits or architectural signatures which could characterize carvel-built ships of the fifteenth and sixteenth century constructed by Iberian shipwrights (the so-called Iberian Atlantic tradition), it has to be accepted that many of the shipwrecks included in this category have not been definitively proved to be Iberian, and indeed a number of these traits are present in ships which have proved not be Iberian (e.g. Gresham Ship: Auer and Firth 2007; Maarleveld et al. 2014). In the later centuries of the early modern period, we know, historically, that significant developments in ship design and construction occurred with well documented examples of both English and French influences certainly during the eighteenth century if not before. The developing Early Modern Shipwrecks database hosted by Filipe Castro at Texas A & M University (a ForSEAdiscovery project partner) proved an invaluable resource in identifying shipwrecks of suspected Iberian origin based on construction features. Chapters 4 and 6 provide up-to-date overviews of our present understanding of the beginning of carvel construction in Iberia and its development during the early modern period.
2. Iberian based on timber usage. Such a definition would require the ship to be built largely or completely from timber derived from trees which had grown in the Iberian Peninsula. This definition was clearly preferred from a dendrochronological and wood science perspective where the application of such techniques would depend on the development of reference datasets from geographical areas within the Iberian Peninsula known to have supplied timber for shipbuilding. Conversely, we might hope/expect to be able to identify oak or conifers imported from Northern Europe given the existence of a growing dense network of ring-width chronologies from these areas. The scope of the ForSEAdiscovery project was ambitious enough in hoping to develop regional ring-width and other reference datasets in the Iberian Peninsula. It was felt that attempting to address the use of timber from the expanding Iberian empires (e.g. Asia and the Americas) was certainly too ambitious. This definition raised a critical sub-question could oaks of specifically Iberian distribution be identified through wood anatomy or other methods?
3. Iberian through commission. The Iberian empires, by definition, expanded beyond domestic territories to include lands in the Americas and Asia, and also possessions around the Mediterranean (e.g. Italy) and the North Sea (e.g. the Netherlands). A ship might be built by a decree of the king of Spain or through "asientos"—where private funding was made available to the State on loan—to serve in war missions under the Spanish crown, even if the ship was built in a foreign shipyard and using timber from distant regions. Equally, ships might be purchased or leased from foreign powers for military campaigns (e.g. the 1588 Armada).

Therefore, targeting the archaeological research of the ForSEAdiscovery project depended on effective collaboration with both historical and wood science researchers within the project team. It should perhaps be stressed that this Marie Curie project focused on the training and development of the participating fellows. Hence the research actions undertaken needed to be balanced against achievable goals within the context of numerous Ph.D. studies, and the development of the archaeological dive team in terms of competence, experience, and qualifications. From the outset, the aspiration was to undertake selective archaeological investigations, predominantly of underwater shipwreck sites where sufficient structural remains of the hull were already relatively well-exposed or being excavated by collaborating external teams/projects.

Given the desire of the wood science team to have "control sites" where the identities of the vessels were known or suspected, and hence historical research could clarify the origin of timber used in their construction, three sites in Galicia were selected for investigation with co-ordination by Archaeonauta SL as an associate partner in autumn 2015. The French corvette *Bayonnaise* (launched 1793, grounded and burnt 1803), located off Langosteira beach, Finisterre provided an excellent training ground for the dive team being located in relatively sheltered, shallow waters. A small area of the hull structure was dredged of overlying sand, recorded with a range of techniques including photogrammetry, and then sampled. This exercise provided the team with the opportunity to test and refine recording, and sampling procedures and put their professional diving training into practice. The second site studied, *Santa Maria Magdalena* (launched 1773 wrecked 1810), was investigated with the assistance of the Spanish Navy's Historic Diving Unit. This investigation is presented as a multi-disciplinary case study in Vol. 2 Chap. 9 which details the combined historical, archaeological, and dendrochronological studies undertaken and initially presented at the IKUWA6 conference and subsequently published in its proceedings (Trindade et al. 2020). Diving conditions were more challenging with more variable visibility and a more extensive site to sample. The third site, a most substantial wreck site first noted in the approaches to the port at Ribadeo in advance of dredging in 2010, was thought to be a vessel associated with the 1596 Armada. Again, the results of multi-disciplinary research on this ship are presented in both Vol. 2 Chap. 3 (authored by the lead archaeologist Miguel San Claudio) and Vol. 2 Chap. 4 (presented by a multi-disciplinary team at IKUWA6, Eguiluz Miranda et al. 2020). The dive team, with increased experience, came to terms with a site with relatively narrow dive windows due to the distinctly tidal conditions in the estuarine location. This site, potentially threatened by existing port activity and possible expansion, has become the subject of a sustained project led by Archaeonauta SL with support from the Junta de Galicia, the Spanish Navy and the Institute of Nautical Archaeology. In subsequent years, diving operations on the Yarmouth Roads wreck in the Solent, UK led by project partner Maritime Archaeology Ltd. pushed the dive team further on a designated historic wreck site with very poor visibility and exacting tidal flows (Rich et al. 2020). This site, subject to earlier excavations in the twentieth century, could be the *Santa Lucia*, an Iberian merchant vessel lost in 1567 off the coast of the Isle of Wight (Watson and Gale 1990; Dunkley 2001; Plets et al. 2008; Traoré et al. 2018). Samples taken from the wreck sites of *Bayonnaise*, *Magdalena*, and Ribadeo provided material for the wood science team on which to test and develop their techniques.

The archaeological team also sought to investigate shipwreck assemblages of suspected Iberian ships which had been previously excavated or, in the case of the Belinho 1 wreck, recently discovered through storm action. The Belinho 1 shipwreck assemblage, washed onto the beach north of Esposende in northern Portugal in the winter storms 2014 and onwards, comprised hundreds of artefacts, and over 70 substantial ship timbers. The recording and sampling of this assemblage was undertaken by an archaeological team led by ForSEAdiscovery partners in 2015 followed up by marine survey and diving operations which located the in situ shipwreck from which this material had been eroded. This project (considered in detail in Vol. 2 Chap. 5) provided an opportunity to blend various developing forms of ship timber documentation including traditional direct measurement and scale drawing alongside multi-image photogrammetry and Faro Arm contact digitisation and the inclusion of systematic collection of dendro-archaeological data from the full timber assemblage (see Vol. 2 Chap. 1).

The nautical archaeology potential of historic reports is perhaps best exemplified by the case study of Lisbon where development over decades has repeatedly led to the discovery of significant shipwreck sites. In addition to re-examining some of these assemblages held in storage (e.g. Cais do Sodre), ForSEAdiscovery also collaborated with teams undertaking post-excavation documentation of ship timber assemblages such as the Boa Vista 1 and 2 ships (Fonseca et al. 2016) and ran workshops to heighten awareness of dendro-archaeological techniques and research potential particularly where urban development in Lisbon is producing new sites. The Delta development in the approaches to the port of Cadiz (see Vol. 2 Chaps. 1 and 6) led to the investigation of three shipwrecks of historic interest. Samples from Delta 1 and 2 were studied by ForSEAdiscovery researcher Marta Domínguez-Delmás (Domínguez-Delmás and García-González 2015; Dominguez-Delmás and García-González 2015), and ForSEAdiscovery partner Nigel Nayling dived on the Delta 3 site to recover samples which demonstrated that this ship was probably Dutch-built and dated to the late-sixteenth century (Domínguez-Delmás and Nayling 2016). Again, this collaboration with major development-led archaeological projects demonstrated how dendrochronology can effectively be integrated within archaeological projects.

The ForSEAdiscovery project also took the opportunity to collaborate with active research programmes on suspected Iberian ships. Renewed research action on the Highbourne Cay shipwreck, Bahamas, one of the suspected Iberian ships included within Oertling's original grouping of Atlantic vessels, was subjected to renewed excavations in 2017. Two members of the ForSEAdiscovery archaeology team (Nigel Nayling and Miguel Adolfo Martins) formed part of the excavation team and undertook observation of in situ timbers and selective sampling and analysis (see Vol. 2 Chaps. 1 and 7). Similarly, samples from the 2017 excavations on the Emanuel Point II shipwreck (one of the wrecks of the *Luna* expedition wrecked off the Pensacola, Florida coast in 1559) were provided by the University of West Florida team, and further samples of the EP II and III shipwrecks were collected by

Nigel Nayling during the 2018 excavations (see Vol. 2 Chap. 1) (Smith 2018; Bendig 2018; Worth et al. 2020).

Beyond site-specific research actions, and the delivery of samples to the wood science team, archaeological research within the ForSEAdiscovery project also supported development of protocols and techniques for shipwreck dendro-archaeological documentation and sampling (Rich et al. 2018; Domínguez-Delmás et al. 2019; Rich et al. 2020), and assisted in the broader ongoing project to develop databases of known early modern Iberian shipwrecks at a global scale (see Chap. 6). Dissemination to academic and professional colleagues was undertaken primarily through engagement with key international conferences, including the International Symposium on Boat and Ship Archaeology in Gdansk 2015 and Marseille 2018 (Litwin and Ossowsky 2017), and the International Congress on Underwater Archaeology (IKUWA) in Cartagena 2014 and Freemantle 2016 (Negueruela Martínez et al. 2016; Rodrigues and Traviglia 2020).

6 Dendro-Archaeology: Wood Provenance and Techniques

In summarizing the range of wood science approaches and results of the ForSEAdiscovery project, this section unashamedly draws on recent technical publications and reviews authored by members of the ForSEAdiscovery wood science team (Domínguez-Delmás 2020; Domínguez-Delmás et al. 2020) The application of dendrochronological techniques to shipwreck assemblages, as a method both for precise dating of the timbers felled for the ship's construction, and to attempt to identify the origin of the timber used (dendroprovenance) has become widespread particularly in northern Europe where a dense network of ring-width site masters and regional chronologies have been developed over the last half century. The temporal extent and geographical density of these reference chronologies is variable and, when considering the early modern period, tends to be most well-developed in regions where there have been long-running programmes of dendrochronological analysis of historical buildings. The organization of these data has allowed for the development of procedures of varying levels of dendroprovenance resolution (Daly 2007). The use of ring-width data alone for provenance of timber is not, however, without its challenges as local site conditions, such as aspect, soil, and altitude can prove significant variables in tree growth—sometimes as significant as climatic variables – leading to potentially misleading results (Bridge 2000, 2011, 2012). The ForSEAdiscovery project, in seeking to both date and provenance timber employed in early modern Iberian ships faced several challenges. The use of dendrochronology, for historical studies, within the Iberian Peninsula was, and still is, less well developed than in other parts of Europe (Domínguez-Delmás et al. 2015). The relative paucity of reference ring-width chronologies covering the last five centuries for the Iberian Peninsula is a fundamental problem. This relative lack of data could not be addressed within the life cycle of single research project—the large number of historical tree-ring chronologies in northern Europe have only been developed through decades of sustained work by a large number of research centres and laboratories. The ForSEAdiscovery strategy was to seek to develop selected ring-width regional chronologies in areas known to have provided timber, predominantly oak and pine, for shipbuilding during the early modern period. This research effort would be complemented by developing other analytical techniques which could assist in refining provenance in timber by integrating ring-width dendrochronology with studies in wood anatomy, wood chemistry, isotopic studies, and ancient DNA.

As part of a precursor project, samples from one of the shipwreck assemblages held in store in Lisbon, the Arade 1 shipwreck, were subjected to dendrochronological analysis (Domínguez-Delmás et al. 2013). Some of these timbers, and also samples from the Cais do Sodre shipwreck, had previously been identified, on wood anatomy grounds as *Quercus faginea*, an oak species with a predominantly Iberian geographical distribution (Castro 2006; Castro et al. 2011, Tables 2–4). Ring-width dendrochronology clearly demonstrated that the Arade 1 oak timbers derived from western France, well outside the natural distribution of *Quercus faginea* and calling into question these identifications. These results challenged the use of microscopic wood anatomical features alone to discriminate between the native deciduous species of oaks found in the Iberian Peninsula and, in some cases, elsewhere (*Q. robur*, *Q. petraea*, *Q. pubescens*, *Q. faginea*, *Q. canariensis*, and *Q. pyrenaica*). The implication was that, based on standard methods of microscopic wood identification (e.g. Schweingruber 1990), these deciduous oaks should be identified only to a subgenus level (*Quercus* subg. *quercus*). This raised the question—how might we discriminate between this group of deciduous oak species, which also tend to hybridize, and hence assist in the identification of timber of specifically Iberian origin?

One approach taken was to examine variations in tree growth rings other than ring-widths (Akhmetzyanov 2019). Using samples from oak forest stands in the Basque Country (six sites) and Cantabria (three sites) in Northern Spain, total ring-width, earlywood and latewood widths, and earlywood vessel area were measured (Akhmetzyanov et al. 2019). Using principal component analysis, it was concluded that combined use of earlywood vessel size (varying response to winter and spring temperature and hence reflecting latitudinal/topographic gradient) and latewood width (varying response to summer temperature) provided the best results in identifying growth site location. These additional tree-ring variables, most usually collected in studies seeking to reconstruct past climate, therefore could have a role in refining dendroprovenancing of timber found in historic buildings and archaeological sites such as shipwrecks and could also assist in discriminating between the different species making up the subgenus group of deciduous oaks (*Quercus* subg. *quercus*). As new methods of non-destructive extraction of tree-ring data from historic material continue to develop, the enticing prospect of being able to collect these data types through use of scanning technologies like MRI, which has the potential to extract digital slices from both waterlogged and conserved archaeological timber, may soon become a reality (Morales et al. 2004; Dvinskikh et al. 2011; Capuani et al. 2020). The use of annually resolved Blue Intensity (BI) measurements of tree-rings has traditionally been used as a proxy for extracting climate data from tree-rings, normally from conifers. Principal Component Gradient Analyses (PCGA) of BI measurements of black pine (*Pinus nigra* Arn.) and Scots pine (*P. sylvestris* L.) on the Iberian Peninsula undertaken by Akhmetzyanov et al. (2020b) demonstrated that this approach can also be used to refine the dendroprovenancing of softwoods from Andalucia and the Central System used for shipbuilding for centuries.

Chemical signatures within wood and timber offered the project a further potential approach in refining our ability to identify the geographical source of timber and the species of trees being exploited – the latter not always possible through traditional visible light microscopy especially for some species which we know, from the historical record, were important resources for Iberian shipbuilding. Traoré, using mainly a combination of pyrolysis in combination with gas chromatography and mass spectrometry (Py-GC–MS) and Fourier transform infrared spectroscopy (FTIR) noted the ability to characterize the degree of degradation of historic building and waterlogged wood, a potentially important advance in the conservation of archaeological wood (Traoré et al. 2016, 2017a). These techniques were used effectively to discriminate between samples from different species of oak within the deciduous oak subgenus group (Traoré et al. 2018), and also between black pine (*Pinus nigra* Arn.) and Scots pine (*P. sylvestris* L.) (Traoré et al. 2017b). As with many of the scientific techniques explored in the ForSEAdiscovery project, the application of FTIR for archaeological wood characterisation shows potential although wood degradation can be a significant challenge.

Isotopic analyses within archaeology continue to broaden their application ranging from provenance through dating to diet. Ratios of stable isotopes of strontium, an example of isotopes independent of climatic variations and dependent on the parent geochemistry had previously been used in attempts to provenance ship timbers (Rich et al. 2012, 2015, 2016). Significant variation in strontium isotope ratios was observed in control sites where both living trees and their surrounding soils were sampled and analysed but analysis of the strontium isotope ratios of waterlogged timbers from underwater shipwrecks still constitutes a challenge (Hajj 2017; Domínguez-Delmás et al. 2020). As timbers become waterlogged and degrade in marine anaerobic environments, their strontium ratios become closer to those of the salt water in which they reside. Hajj's pioneering work points the way to the development of extraction techniques which may yet overcome this challenge.

Advances in the extraction of ancient (a)DNA are revolutionizing bioarchaeology as a branch of scientific archaeology. Groundbreaking work on the extraction of (a)DNA from archaeologically recovered wood including oak heartwood both highlights the challenges faced, but also offers the prospect of a further, parallel and independent line of analysis of waterlogged wood which seemed unlikely to prove feasible just a few years ago (Wagner et al. 2018; Domínguez-Delmás 2020; Akhmetzyanov et al. 2020a).

7 Conclusions

The ForSEAdiscovery project was truly innovative and ambitious in attempting a well-integrated multi-disciplinary research project. Its legacy is diverse and substantial in terms of the young researchers who developed as Marie Curie fellows working together cutting across the disciplinary and methodological barriers which so often define research and, in the process, publishing across the disciplines of history, archaeology, and the earth sciences. The two volumes of this publication include many contributions from members of the ForSEAdiscovery family which further demonstrate the progress made in recent years. This is not to say that our work in understanding the interaction between the Early Modern Iberian empires and forest resources at a time of unparalleled maritime expansion is complete. New understandings and refined techniques offer us the opportunity to push forward this line of research within a broader context of human/nature relations which could be defined as Environmental History. Such advances require the research community, across disciplinary silos, to engage in continued collaboration only achievable through transformative acts of consilience.

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Chapter 3
Life and Death in the Spanish *Carrera de Indias*: Ships, Merchants, Cargoes, and Routes

Ana Crespo Solana

Abstract It has been said that sunken ships tell the story of those who reached port. Indeed, the vast amount of information available in historical documentation, as well as that processed in different databases, repositories, and Geographic Information Systems (GIS), offers an extensive, rich, and suggestive panorama on history beyond the ships, their ocean voyages and the people who inhabited them. These narratives of knowledge imply the establishment of big data available for the historical archaeology of the Iberian ship as a space in movement, as a Foucauldian *heterotopia*, a different space, a mythical and real contestation of the space in which we live, a real space, out of all places (Foucault 1984).

1 The *Great Convergence* and the Iberian Atlantic World

It has been said that sunken ships tell the story of those who reached port. Indeed, the vast amount of information available in historical documentation, as well as that processed in different databases, repositories, and Geographic Information Systems (GIS), offers an extensive, rich, and suggestive panorama on history beyond the ships, their ocean voyages and the people who inhabited them. These narratives of knowledge imply the establishment of big data available for the historical archaeology of the Iberian ship as a space in movement, as a Foucauldian *heterotopia*, a different space, a mythical and real contestation of the space in which we live, a real space, out of all places (Foucault 1984).

At the end of the fifteenth century there was a great convergence derived from the densification of the oceanic routes opened by Portugal and Spain. Some aspects of the current debate on globalization already took place in those decades of transition

A. Crespo Solana (✉)
Instituto de Historia, Consejo Superior de Investigaciones Científicas (CSIC), Madrid, Spain
e-mail: ana.crespo@cchs.csic.es

A. Crespo Solana et al. (eds.), *Heritage and the Sea*,
https://doi.org/10.1007/978-3-030-86460-6_3

from the fifteenth to the sixteenth century: the great expansion of trade in goods, although still without the comparative advantages that act today at the level of country sectors, but driven by the revolution in maritime technology (the ship and navigational instruments), the lowering of prices of sea transport and trade finance, cartography, and the unprecedented extension of oceanographic knowledge. This was the first global age or first globalization due to the dramatic increase in exchanges of people, products, and cultures and, although an uncertain debate still prevails, the primary assumption characterizing this period is the idea of a multi-level interaction characterized by the continuous creation of moving space beyond political, ethnic, and socio-cultural boundaries (Pietschmann 2002; Yun-Casalilla 2019). However, the emergence of inequalities as consequences of the disparate densification and extension of social and spatial networks, with long-term consequences, is also discussed. The divergence produced by the crisis of the seventeenth century has also been emphasized, with determining implications in the framework of the currently called entangled connection: "The Atlantic world was to be a history of the interactions of all the lands and people facing the Atlantic. The ocean would not be divided; it would bring together"(de Vries 2018).

Historical studies are abundant in narrative and teleological discourses on the analysis of these processes, but still demand a complementarity from the archaeological perspective that contributes not only to the deepening of technical and material analysis but also to the opening of new lines of interdisciplinary research. Unfortunately, the *Carrera de Indias* has been less the subject of historical archaeology, except for honourable exceptions that value the importance of the Iberian ship as an object of study in its continent and content, as well as a connecting route in the creation of the maritime landscape of that first global age (Bass 1963; Castro 2005). George Bass contributed to the consolidation of the methodological framework of a systematic underwater archaeology with the aim of reconstructing the historical-cultural context of a given site through the careful study of the cargoes and artifacts transported on board: "The primary duty of the field archaeologist is to record and present the smallest details of his excavation so that the proof of his interpretation is readily available to other scholars" (Bass 1963).

A closer look at this narrative reveals the contribution of Iberian navigation from the fifteenth to the eighteenth centuries to the great convergence of the first globalization characterized by the decisive role of Spain and Portugal in the stimulation of world trade, the price revolution, the massive production of gold and silver, the extension of maritime routes and the new cartography of planet Earth as seen from the ocean. In the case of the Race of the Indies, 1502 appears as a key date in the construction of the idea of the "Mar Oceána" (Ocean Sea). It coincided with the dissemination of the so-called Cantino Planisphere, perhaps drawn up by an unknown Portuguese, but discovered by an Italian spy, Alberto Cantino, which, although still preserving medieval etymologies, showed the coast of Brazil, the meridian of the Treaty of Tordesillas of June 7, 1494, and the "Antilles of the King of Castile" (Mendonça de Alburquerque 1967). The same period saw the inquiries about the new colonies made by Francisco de Bobadilla, his landing in Santo Domingo in August 1500, and the trial against Columbus who returned to Spain in chains after his third voyage, between 1498 and 1500. Judge Bobadilla died in a shipwreck during his return to Spain due to a hurricane that Columbus himself had predicted. On that voyage he finally sighted Tierra Firme, after a previous stopover on the island of Trinidad. His fourth and last voyage would also begin in 1502 after the favourable review that Nicolás de Ovando made of Columbus' enterprises and that Ovando himself, soon appointed Governor in Hispaniola, would support with a first large colonizing fleet bound for the New World, departing that same year from Sanlúcar de Barrameda (Mira Caballos 2014).

Since then, shipwreck narratives have been inherent to the odyssey of ocean navigation itself. That moving space of the Iberian ship was always subject to the "inhuman fortune", to the imperfection of the pilots, in its case, the catastrophic misfortunes of the sea, which in a prevailing way contributed to build a maritime, or oceanic, landscape full of mythologies and legends. In 1702, two centuries after the events surrounding the great convergence of 1502, an event took place that would change the Spanish crown's view of shipwrecks during battles and would encourage the control that the new Bourbon government would have over the "shipwrecks" and their context. The Battle of Vigo, which took place in the Strait of Rande and San Simón inlet on October 23, 1702, pitted the New Spain fleet of Admiral Manuel de Velasco y Tejada against an Anglo-Dutch squadron in the context of the War of Succession to the Spanish crown. The events after the battle and sinking of those valuable ships were contradictory in the face of the pressures of the Consulate of Seville so that the cargo was not unloaded. Unpublished documents confirm two important facts related to the cargo of the galleons: first, at least 25% of the gold and silver belonged to Amsterdam trading companies that had participated as shippers in the fleets through their partners based in Cadiz; second, after the shipwreck, an inquiry carried out in the Council of the Indies by the prosecutor Bernardo Tinajero de la Escalera on the corruption and theft perpetrated by the deputies of the Consulate of shippers during and immediately after the battle, the Seville consuls were charged with having stolen 140,440 pesos of the 606,000 that were on board the fleet of Manuel de Velasco, and with having proceeded illegally with the ransom of this merchandise.[1] Apart from the King of Spain's wealth, the fleet was carrying more than three million pesos belonging largely to private individuals, many of them foreigners (Crespo Solana 2000).[2] The sunken ships were thus plundered by the very individuals who were supposed to protect and control them. Centuries later, treasure hunters of different nationalities were allowed to plunder many other shipwrecks, as Robert Sténuit did with the Rande wrecks.

These two exemplary historical events also underline the obviously necessary methodological convergence in studies on maritime archaeology and historical shipwreck literature. Moreover, they underline a number of aspects that current

[1] BNE. Mss 12,055. Report of Bernardo Tinajero de la Escalera, fiscal of the Board of Trade in the Consejo de Indias.

[2] BNE, Mss 12,055. Letter of Francisco Mier del Tojo, to Cristóbal Esquella, 31 of march, 1704, fol. 4.v.; Nationaal Archief (N.A), 1.03.01 *Inventaris van het archief van de Directie van de Levantse Handel en de Navigatie in de Middellandse Zee, (1614) 1625–1826 (1828)*, 279.

historical and archaeological research might question: the true routes and voyages, not always in accordance with the impositions of the Spanish crown; the true nature of the shipwreck events; and the debate on the ownership of the misnamed "treasures". These voyages back and forth evoke the spatial-temporal framework of maritime expansion over the Atlantic Ocean. Columbus' fourth voyage in 1502 actually delineated what would later become the usual route established for the fleets and galleons that linked this oceanic route for centuries. The catastrophic event that occurred in the Bay of Rande, off the coast of Galicia, in 1702 serves to situate a narrative of shipwrecks as habitual and sadly familiar episodes inherent to this historical narrative in which, on occasions, saving cargo took precedence over human lives (Pérez-Mallaína Bueno 2015).

The existing documentation on shipwreck salvage, trials, and inquiries into the vicissitudes that occurred on board, during the catastrophe, during the battle, upon reaching port, etc., offers information of a rich narrative barely glimpsed and understood, despite the remarkable studies from the social and anthropological, historical, and archaeological perspective (Trejo Rivera and Pinzón Ríos 2019). The historical framework is still subject to research and debate that, thanks also to new digital technologies, allow the possibility of raising new questions and revising false topics. Apart from placing this problematic in a context of global analysis, the perspective of historical archaeology offers more information on the historical-spatial logic of this navigation and the narrative it created. Henri Lefevre defined the concept of production of space in a methodology applied to the urbanization of human societies from a sociological perspective. However, the production of space determines social relations in a certain spatial-temporal nexus, in the evolution of mercantile capitalism, in which space is a commodity in itself, and which transforms the idea that products were produced in a certain location to be on the move beyond land borders (Lefebvre 2012). From that perspective, the archaeologist, like the historian, is also a "creator" of space, constructing and de-constructing it (analytically undoing space itself to give it a new structure) under the lee of the analysis of documentary and material evidence. Space intervenes in production itself: organization of work, transportation, flow of materials, people, and energy. The ship is thus the container and creator of this space in movement. Both premises, space in movement and ship as production of such space, seem to influence a historical-archaeological research that materializes this epistemological and philosophical approach by creating an adequate theoretical and methodological framework.

The *Carrera de Indias* was a maritime and cultural landscape that housed, in turn, tangible and intangible heritage, with its set of creations and its role in the transfer of knowledge. It was not simply, as it has sometimes been defined, the route of the treasure fleet, but the *Carrera de Indias* implied a transmission and conduction of memories, apart from relating, in its historical analytical context as the set of activities and businesses linked to the historical biography of the merchant of the Indies and other social agents. The *Carrera de Indias* was a complex, dynamic, and non-linear system referring to a landscape in continuous evolution and with bifurcations not always visible in which social and spatial networks interact (Owens 2007; Crespo Solana 2014).

But what kind of system was this maritime landscape of the *Carrera de Indias*? The processes linked to its configuration, development, and evolution are inherent to the patrimonial heritage that led the ships that sailed these routes, the cartography they made of planet Earth and the historical events they described. The ship of the modern age is a historical heritage artifact, scarcely valued in its true meaning, and constitutes an object of study both as container and content. It is also a connector of memories and is a part of the maritime and underwater cultural landscape. To this end, it must be studied in its geographically integrated historical framework by analysing empirical and descriptive narratives of the landscape, present in memories, routes, and stories of each era. In reality, the Spanish *Carrera de Indias* was like one more layer of the connected world of that first global age, a part of the complex system of interactions that also defined the Portuguese transoceanic system, from Lisbon to Goa and Brazil. It signified the beginning of the "great convergence". A large part of the agents participating in this Spanish-colonial mercantile system were a transmigrant and transient labour force, who settled in communities or "nations", settled mainly in port cities where they arrived aboard merchant ships (Crespo Solana 2011). They were merchants, artisans, shipbuilders, wholesale traders, noblemen, and aristocrats engaged in commerce, who travelled temporarily for various political or economic reasons or for religious exile. Many of them were genuine refugees who sometimes found a home in the settlement areas. Both European and American ports connected to the *Carrera de Indias* exerted a great attraction on these agents who saw the fleets of the Indies as good routes for mobility.

For centuries, this system functioned geoestrategically: it linked the main port centres of America with the cities of the Crown of Castile, constituting a maritime lifeline. The most important aspect to understand the creation of this system was its geographical base, the Atlantic Ocean in a first stage, to extend globally to other maritime spaces in a relatively short period of time. The construction of this maritime, geopolitical and socioeconomic landscape determined the global movements of interconnection from the fifteenth century onwards, establishing a process of acculturation through the mid-Atlantic route of the "trade winds", between regions from Western Andalusia, Galicia, Atlantic islands (the Macaronesia), the Caribbean Gulf, and regions linked to what would be called the "South Sea". In his Panegyrics, João de Barros said that these expeditions were hardly led by "rustic pilots, with no more speculative letters than a single doctrine applied in the deck of a ship".[3] Most of them were indebted to the Mediterranean naval schools, to the Sagres school in Portugal, to the Basque-Cantabrian tradition and to the contacts between Mediterranean and Andalusian sailors that between the thirteenth and sixteenth centuries nourished the knowledge about the secrets of the ocean, its limits and the desire to search for more products to trade.

Anglo-Saxon historiography, the intellectual creator of the Atlantic History line of research, notably marginalized the importance that the Iberian empires had in the

[3] Joâo de Barros, *Panegíricos*, 1496–1570. (Panegírico de D. Joao III e da Infanta D. Maria). BNE R: XX2299972.

processes of global integration, and the fact that an abundant existing literature written in Portuguese and Spanish has been ignored is striking. Despite this, the historical archaeology of the *Carrera de Indias* is rich in empirical research and teleological narratives, although it still lacks more scientific historical-archaeological studies. These sometimes suffer from a mediatized dissemination that has made "the trees blind to the forest". Nevertheless, the vindication of the "spatial turn" (Knowles 1999), oriented to visualize data on maps, as well as space itself as a unit of analysis, offers new possibilities for the understanding of the integration of societies and geographical entities, and the analysis of the dynamics of global systems of interaction between 1400 and 1800: a system self-organized from its spatiality and from the networks of agents that from the first voyages of discovery and colonization were participating in the socio-political and cultural construction of the same. This is why the concept of "entangled" has emerged to speak of a history connected to geography and to cultural heritage, both tangible and intangible. This line of work has also affected the study of the ocean as a recipient of anthropic technological and social impact, explaining the impact of networks of agents in the formation of the historical-cultural space (Crespo Solana 2016; Cañizares-Esguerra 2018).

In the case of Spain, the *Carrera de Indias* system began around 1492, the year of the first voyage of Columbus, and lasted until the end of the trade monopoly system with America and the subsequent closure of the *Casa de la Contratación de las Indias* in 1790. During this spatial-temporal framework, Spain and Portugal contributed not only to the opening of events producing this new maritime space, but also to the spatiality of ports and regions, as well as regional specialization. This relationship between Spain and Portugal was intense especially during the Iberian Union (1580–1640) during which Portugal emerged as a veritable "shadow empire" of the Habsburg Hispanic Monarchy. Managed from Lisbon's *Casa da India*, the Portuguese trading network was the result of a long process of expansion. During the fifteenth century, Portuguese ships explored the west coast of Africa, in the following century they explored the South American continent and engaged in trade with the local populations on the coasts of Africa and the Indian subcontinent. By the mid-sixteenth century Portugal had built a large trading network supported by forts, factories, and cities and there were Portuguese merchants in the Moluccas, Timor, Bengal, Pegu, China and Japan.

At the same time, the various port cities both in Europe and in America where the fleets of the Indies arrived, reconfigured old routes already known since antiquity, mapped in portolans and maps, and even opened new sea lanes, while attracting various other inland routes for the channelling of various products and the introduction of new ones. This also contributed to the consolidation of maritime-river port systems, which were highly developed during the centuries of classical modernity and which, in part, explains why, in the cartographic displays currently elaborated on these historical narratives, ports and even important archaeological sites appear far "inland" near waterways that have been covered or reclaimed from the sea.

Since 1503, the year of the creation of the *Casa de la Contratación* (Spanish Board of Trade), this oceanic system had an institutional organization chart that sought two things that it did not always achieve in the long historical time: first, to impose a centre of geographical domination to power and wealth with control in a single port; and second, to regulate, order, and control the private trade that was made from Spain to the colonies, and in which participated several scales of the social spectrum of the time, nobles and aristocrats and, especially, many foreign and native merchants and business people. The maritime space of the *Carrera de Indias* can be defined as "maritime activity between the Iberian Peninsula and the American colonies as well as every business and other endeavour related to that activity. When a trader engaged in American trade by loading his merchandise onto the fleets and galleons, it was said that he was involved in the *Carrera de las Indias*. After all, this term defined a historical category that entailed the development of a definitive way of life, which was strongly linked or even subjected to, the evolution of a specific, but not limited, mercantile-geographical system, for this system was connected to other trading areas that did not belong to the Spanish empire but were intrinsically linked to it" (Crespo Solana 2011). The institutional basis was the *Casa de la Contratación* (in Seville from 1503 and from 1717 moved to Cadiz); the Council of the Indies (1543); and some Consulates of Commerce, founded, respectively, in Seville (also in 1543), in Mexico (1592), and in Lima (1613). Later, a very active consulate of Cadiz was created during the eighteenth century (Bustos Rodríguez 2017). Despite the politicized, mediatized, and supervised nature of the Indies trade, business, finance, and shipbuilding were mainly in private hands. The organization and preparation of the fleets and navies, although controlled by the *Casa de la Contratación*, also involved the active participation of private businessmen and assistants, creating an authentic complex network of businesses around the fleets of the Indies in which illegality, corruption, and fraud were never lacking.

2 Indias Fleet

Two official maritime lines were established between Spain and America, governed by the Crown of Castile in its eagerness to create a monopoly that soon became a kind of public-private negotiating company. Privatization was due to the confluence, from the capitals of the empire ruled by the Habsburg dynasty, of multiple networks of mercantile agents who financed these oceanic businesses. The sea became the target of a multinational encouraged by the Iberian imperial administration. From the first year of the American colonization, the Crown of Castile had great experience in the organization of fleets, navies, and squadrons, such as the armada of Nicolás de Ovando (1501–1502) or the Great Armada of Castile del Oro (1513–1514) (Mena García 1999).

The years from 1517 to 1519 were decisive for the ideological configuration of the "four parts of the world", coinciding especially with the circumnavigation of Magellan and Elcano (Gruzinski 2010; Colomar Albajar 2018). Soon, drafts sent to the Spanish Crown were debated on how this navigation system should be regulated and even what types of ships were the most suitable as merchant and as warships or both at the same time. A decisive date for the definitive adoption of the convoy system was undoubtedly the attack carried out in 1522 by Giovanni da Verrazzano, known in France as Jean Flory, after having obtained a privateering patent from King Francis I of France, at that time at war with Emperor Charles Habsburg. The French fleet attacked the Spanish fleet near the Azores Islands, dismantling it and seizing the riches it was carrying. In that same year a plea to the King by ship-owners from Seville led to the opening of a debate on the protection of ships, but it was in 1555 when the Guard Fleet of the *Carrera de Indias* (Flota de la Guarda) was created (De Solano 1993). Nevertheless, the convoy fleet was a common practice to avoid corsair attacks in other scenarios, such as trade with Flanders. These two fleets sailed with more regularity than has been described, although subject to change and alterations of routes and stopovers related to the inclemency of the weather and the conditions of arrival at coasts and ports. What was called "preservation of the fleets" continued to be the usual practice, although it only began to be regulated in various ordinances, in 1527, 1543, 1554, until in 1564 the organization of two fleets was configured, one for New Spain and the other for the Isthmus of Panama, which would later be called *Galeones de Tierra Firme*; one in March and the other in September, respectively. The continuous threats of an inhospitable and surprising ocean gave rise to a veritable arms race and the proliferation of various navies, such as that of the Ocean Sea formed by galleons of the Portugal Squadron based in Cadiz, La Coruña, Seville, Santander, and Lisbon. The Portugal Squadron was a combined fleet reflecting the Iberian Union (1580–1640) during the reign of Philip II.

The public–private enterprise survived for almost three centuries in cooperation between the institutional framework imposed by the Crown, the Kingdom of Castile, on the one hand; and an immense network of mercantile agents and new socio-professional categories emerging under the protection of the new developments of industries, technologies, and financial instruments related to ocean navigation. But it had its limitations. Despite the consolidation of such an extensive port geography, in Spain the preparation of the fleets and galleons in the port of departure, called *apresto*, was carried out in a single port: Seville was, from 1503, the official head of the fleets, the Guadalquivir River; but throughout the seventeenth century Cadiz and other coastal areas (Sanlúcar de Barrameda and El Puerto de Santa María) became the port of arrival (*Puerto de arribadas*). The centralization of the preparation of fleets and galleons in a single port (Seville, in 1503, and Cadiz, from 1717) has, to a large extent, distorted the historiography of the Spanish *Carrera de Indias* by defining an idea of monopoly that, in reality, never existed (Oliva Melgar 2004). But in practice this was a chimera characterized by continuous arrivals at ports that had permission to do so, such as Sanlúcar de Barrameda and Cádiz or the coasts of Galicia. These arrivals were made both to ports in America and the Iberian Peninsula; and the reason lies precisely in the very geography of the trade winds in the mid-Atlantic and by a host of "accidents of the sea" and events that affected the fleets and that has resulted in archaeological remains of these ships being found near the ports of Portugal and northern Spain. In fact, the one-port policy was already broken by 1529 and other peninsular ports welcomed the arrival of fleets: La Coruña, Bayona, Avilés, Laredo, Bilbao, San Sebastián, Cartagena, and Málaga, the latter two even had permission to load in fleets from the Indies (Chaunu and Chaunu 1960; Crespo Solana 2014). This was so, although in 1573 Philip II insisted on centring the monopoly in Seville. However, in 1668 the fleets began to admit cargo, officially, in Sanlúcar de Barrameda and Cádiz, establishing a Juzgado de Arribadas (Díaz Blanco 2017).

The preparation (*aprestos*) of the fleets implied a complex naval, fiscal, and commercial organization. Beginning in 1561, a legal corpus was established that basically stipulated the preparation of two annual fleets, one in January and the other in August. However, these departure dates underwent various changes as the rocky Antillean coasts were mapped and the wind systems, currents, and hurricanes became known. In some years, the fleets and galleons sailed integrated in a single large convoy, separating in the Antilles into two lines, one for Veracruz and the other for the ports of *Tierra Firme*. The ships had to be well armed, but in case of war they would be accompanied by the flotilla known as the *Armada de la Guarda de la Carrera de Indias*, created in 1555 and which operated until the Navigation Ordinances of 1564 (Mira Caballos 1998). In 1556 the concept of the fleet of the Indies began to be used, with the intervention of Pedro Menéndez de Avilés (sailor and *adelantado* of Florida, and later governor of Cuba, and captain general of the fleets of the Indies), in a memorial written in 1556 (Mira Caballos 2006).[4]

Long before that date, the idea of sailing ships in convoy ("*en conserva*") had already been developed to provide an effective defence against possible dangers at sea during the voyage. The memorial of Pedro Menéndez de Avilés stipulated the departure in April and October, a common trend especially from 1569 onwards. Nevertheless, the divergences in the months of departure of the fleets and galleons continued to occur, as well as the departures of the returning fleets from the American ports to Europe due to the complexity of their preparation and organization in the port. In practice, this Spanish *Carrera de Indias* did not differ from the Portuguese one except in the routes, more focused on the route between Lisbon and Goa (and vice versa) in the case of Portugal, shortly after the discovery of the maritime route to India by Vasco da Gama when he inaugurated the route of the Cape of Good Hope (Contente Domingues and Ingham 1998; Contente Domingues 2008). In both cases it was a functioning mechanism that also encompassed private business and shipbuilding (Domingues and Polónia 2018; Valdez-Bubnov 2018).

In April, the Fleet of New Spain sailed to the Antilles and Gulf of Mexico with a definitive stopover in Veracruz, specifically in San Juan de Ulua, after a stopover in Santo Domingo. The two fleets were thus differentiated, but on several occasions, they continued sailing together, separating when they reached the Caribbean. An analysis of mapped data in the web viewer on shipwrecks shows that, despite this differentiation, both fleets and galleons sailed together on their way back to Spain, especially when they crossed the Bahamas Channel and circumnavigated the coasts of Florida.[5] In August, the galleons would leave Tierra Firme for Panama, stopping

[4] AGS, Consejo de Castilla 46, doc. 38.

[5] Cf. Chap. 13 in this book.

in Nombre de Dios and later in Portobelo from 1598. Cartagena, located in what was then called Nueva Andalucía, would become the great port capital of the galleon fleet. Both fleets wintered in Havana in March or April and from there departed back to Spain with the wealth of the Indies and the returned goods belonging to private merchants. Soon, the fleets of the Indies were the main means of communication between Spain and the viceroyalties of Mexico and Peru. Their regulation went through several phases until their definitive organization. The intention of this system of fleets and galleons was to connect a key geographical framework, from Veracruz, in Mexico, Havana and other minor Antillean enclaves, Panama (with Nombre de Dios and later Portobelo) and the northern coasts of South America. These were regional enclaves of strategic-commercial interest in the heart of this maritime empire, which was fed by rapid and rich economic growth and inter-American commercial development. The route of the fleets and galleons was adapted to the trade winds, crossing the Atlantic in a navigation of arduous voyages, starting in the Mares Sea to the Canary Islands, which could take up to 2 months. According to Serrano Mangas (1991), the routes were not always fixed despite the wishes of the Spanish Crown. The Tierra Firme fleet sometimes went further south on the outward voyage and passed through the channel between Trinidad and Tobago. The fleet of New Spain opened unique routes that forked between the islands of Barlovento, Santa Cruz, Puerto Rico, Hispaniola, Cape Tiburón, Cape San Antonio, Cape de la Cruz, Isla de Pinos, and Cape Corrientes, areas where today lie submerged sites of great archaeological value. The same happened on the return voyage through the Bahamas Channel, given the fleet's north-westward course between the Virginia and Bermuda Capes and the subsequent voyage to the Azores Islands.

Indeed, due to the dangers of the sea, navigation was increasingly established in "conserve"; as stipulated in the legislation created between 1561 and 1564. The most hated danger, in the first decades were the possible attacks by enemies, although, in reality, these fleets were more vulnerable to the weather (hurricanes between September and November) and to the rocky geography and reefs of the Antilles, or the "shallows" of the sandbars, such as Sanlúcar de Barrameda.

3 Port Geography in the Americas

The coordination of the departures and arrivals of the fleets and galleons to America had to be done in connection with a complex spatial geographic network of provisions, routes, and supplies. Given the difficult and insecure situations and the inclement weather, the successful development of this system was almost miraculous. The literature of shipwrecks is full of impossible routes and accidents, precisely related to this lack of connection between routes. This chain of fleets was vital for the financing of the wars of the Hispanic Monarchy, but from the end of the sixteenth century and especially throughout the seventeenth century, Spanish navigation of the Atlantic shared the space with the expansions of other nations, turning the Caribbean and the small Antilles into an Achilles heel of the Habsburg Empire. Due to the eagerness to get hold of gold and silver, Spanish colonization focused too much on the continent, leaving behind open flanks through which strong influences entered and soon turned the Antilles into a preferred area for smuggling and piracy. The increasingly recurrent presence of foreign fleets in the regions near the colonies led to the promotion of navigation to some areas marginalized from the fleet system. In 1627, a navigation of ships of registry to the Guyana began[6]; and something similar also happened with the coasts of Venezuela. In the second half of the seventeenth century, the voyages of "Register" ships (*Navíos de Registro*) began to be organized, which linked marginal coastal areas to the fleets and galleons and also included a new regular navigation to the south of America, especially to the port of Buenos Aires.

The terminals of the fleets in America, mainly Veracruz, Cartagena, and Portobelo had connections with subsidiary routes, auxiliary fleets that linked the ports of the Caribbean Gulf with other areas of America, especially also with the South and North Pacific. The port network of this logistic system also included Havana, for trade with the Caribbean, and Acapulco for trade with the Pacific. The layered superimposition of the different routes of these fleets, both main and inter-American, together with those of the different organized navies, implies a true palimpsest of maritime networks and spatial connections. Their visualization in a GIS is feasible but, for the moment, these visualizations show incomplete narratives with the addition of countless enigmas reflected in the identification of submerged archaeological sites produced throughout this history. Many of these shipwrecks are not related to the official routes so we can raise alternatives not always collected in the historical documentation. The existing thematic cartography on the main commercial ports is abundant and it is possible to appreciate how, as the ports were integrated into the commercial system of the European networks, they were reflected in the cartography. On many occasions their presence meant the disappearance of other nodes of lesser importance in the collective imagination of the old world, as happened, for example, with Nombre de Dios, former headquarters for the arrival of the galleons that was replaced by Portobelo as the former was a dangerous location on the coast of Panama and close to the Chagres River (López Díaz 2019). The elaboration of this cartography definitely contributed to the construction of the mythical oceanic landscape of the *Carrera de Indias* and even the image we have of the world today (García Redondo 2018).

Indeed, the ports of the Indies played a major role in maintaining this spatial logistics (Guimerá Ravina 1999). Veracruz was the capital of the New Spanish fleet in America, in the Viceroyalty of Mexico, but what happened in its port when the fleet hibernated had a global impact from 1519. The foundation of San Juan de Ulua, rapidly fortified in successive stages following the landing of Cortes, cannot be separated from that of the Villa Rica de la Veracruz. It soon became a military zone especially after an epic episode that determined its historical evolution: the Battle of San Juan de Ulúa in which the armada of the Spanish fleet commanded by

[6] AGI, Contratación, 1694.

Francisco de Luján had to face an English fleet commanded by Francis Drake and John Hawkins in 1568. The decades from the foundation of the viceroyalty of New Spain in 1535 until the end of the sixteenth century were relevant in the context of the Anglo-Spanish wars, especially due to the great instability of a wide geographical area that escaped political-military control. Throughout its history, the viceroyalty, as well as the entire Gulf of Mexico, had become a commercial society that lived mostly from interregional trade and the benefits of the arrival of the fleets. In 1673, the viceroy Marqués de Mancera pointed out the problems related to the incursions of foreigners, which were not only illegal trade, smuggling, and the malicious arrivals of unauthorized ships, but also the ineptitude and corruption of the Hispanic-Creole authorities. It was for this reason that later Viceroy Payo Enriquez de Rivera, viceroy until 1680, reformed the Windward Armada in order to further protect against piracy in the Gulf of Mexico (Torres Ramírez 1981). At the beginning of the War of Succession, Veracruz was a vital point for fraud in cocoa entries from Caracas, Maracaibo, Cumaná, and Trinidad de Barlovento. It was known that these goods were introduced in the Spanish fleets themselves, registered in the name of foreign merchants residing in Spanish port cities. In 1699 the Viceroy of New Spain, Count of Montezuma, had the duty to investigate these crimes and send a report to the court in Madrid, but claimed that it was difficult to prove. In the Court it was thought that reinforcing the construction of the castle of San Juan de Ulua, and even extending it to the islet in front, could be a solution to control this, but the truth is that the military option was not the way to solve the weakening of the control over the commercial monopoly and over the comings and goings of fleets.

From the Viceroyalty of New Spain, colonization campaigns were developed in territories adjacent to the Gulf of Mexico. The viceroy Duke of Albuquerque (1702–1710), faithful to the Bourbon cause, strengthened the presence of the Windward Armada, but his successor, the Duke of Linares (viceroy between 1710 and 1716) had to allow the opening of the port of Veracruz to the English due to the privileges they received preceding the Treaty of Utrecht. The "Asiento de Negros" (a special contract between the Spanish and British Crown to introduce black slaves to America) gave the English the exclusive right to supply the Spanish colonies with African slaves (Donoso Anes 2007). From 1716 onwards, French incursions were common in the north of the viceroyalty while Danish merchants had established themselves in the islands of San Juan and Santo Tomás; and Englishmen in the Laguna de Términos, Yucatán, and Belize who received help from Jamaica (Ojeda 1994). Expeditions to Florida were repeated on several occasions because it was geoestrategically important due to its location near the port of St. Augustine, the Bahamas channel, and Virginia to the north, where there were French populations, in addition to being close to the Appalachian area, full of "unsubdued" Indians, with shores full of sandbanks and shallows.[7]

Two important phenomena marked the development of this oceanic navigation: first, the emergence of a mercantile economy in America controlled by Creoles,

[7] *Proposiciones del Marqués de Varinas … ..* (passim).

officials of the institutions, and members of the Consulate of Lima and Mexico. Also related to the *Carrera de Indias* were a good part of other groups in the social scale of viceregal America, ranging from local chieftains to foreign merchants. Secondly, the creation of a series of fleets subsidiary to the main maritime routes imposed by the Spanish crown and which developed an important role of regional economic interconnection, as well as propelling shipbuilding centres in America. These American naval industries competed with shipyards and arsenals in Spain by supplying American-built ships, especially from the mid-seventeenth century onwards. Apart from the fleets of New Spain and the galleons of Tierra Firme, there were other fleets and navies that were established over time as a result of both defensive needs and intraregional trade that was forming in several "Mediterraneans"of the Americas, especially in the Caribbean. In addition, there were also fleets or flotillas of ships *de Registros y de Avisos*, loose ships, an endless number of auxiliary fleets, with all kinds of vessels, which came to sail to America outside the fleet system. This is less well known, but it is enough to read the memorials of some of the ministers who were in charge of the *Casa de la Contratación* to understand this. One such example is the Memorial of Francisco de Varas y Valdés who sent a valuable report to the Crown justifying the organization of fleets and navies in Cadiz from 1711.[8]

Thus, apart from the two main fleets of *Nueva España* and *Galeones de Tierra Firme*, there were other subsidiary fleets that little by little interrelated distant spaces and integrated them with the main polygon of ports that linked the official navigation system. Small flotillas navigated other routes that linked marginal areas of the empire where an active interregional trade had developed, and which eventually became a strong competition for the main economic route of the fleets and galleons. The auxiliary fleets were intended to connect places of American production and exploitation with the neuralgic centres of the fleets and galleons in their mission to return to Spain the resources of different zones of America. These auxiliary fleets were mainly three: a Caribbean fleet and two fleets in the southern and northern Pacific.[9] These last two fleets moved commercial circuits that went as far as the Río de la Plata and the Philippines, entering the Pacific Ocean. These alternative fleets integrated marginal zones to the route that linked the two great viceroyalties, extending this space to the entire region of the Río de la Plata and the coast of Chile. In theory, the auxiliary fleets were supposed to place their merchandise within reach of the fleets of New Spain and Tierra Firme as soon as they arrived from the metropolis, but the reality is that this almost never happened due to multiple factors, including technological handicaps, the enormous distances they had to cross in the midst, at times, of unfavourable winds or storms, and the delay in negotiations due to the complex procedures between merchants. The lack of timely connection between the fleets of New Spain and the galleons with the rest of the inter-American fleets had an even greater impact on the irregularities in the organization of the fairs (*ferias*)

[8] MNM, Memorial de Francisco de Varas y Valdés.

[9] Cf. Chaps. 23 and 24 in this book.

where some of the main economic exchanges took place to produce the so-called returns and the arrival of these to the ports of Veracruz and Portobelo where they were to embark for Spain. In fact, it was during these returns that all kinds of frauds were practiced, as many goods were shipped without being registered (Flores Moscoso 1991, p. 268).

The circuits of this intercolonial traffic created economic centres in the Caribbean, the Pacific, the South Atlantic and around the Lima-Potosí-Buenos Aires axis. Considering the difficulties imposed by the geographical environment and the lack of an adequate network of overland roads, it should come as no surprise that, in three of the aforementioned circuits, the maritime route was also used for commercial exchanges. Nevertheless, the American connection was enriched by new projects for land and sea routes, especially in the eighteenth century (Stangl and Stangl 2020). Through these circuits, commercial products and also silver were transported. The overland connection between the production and marketplaces and the port network of this maritime system was also very complex. The communication between Veracruz and Acapulco was made through a road that crossed Mexico from coast to coast and through which the Mexican silver that came from the North and went down from Mexico to the coast also transited. The communication from Panama to Portobelo, some 60 miles, was made by means of a small road called De Cruces, which flowed into the upper part of the Chagres River, then used to connect with Portobelo. It was a trans-isthmian route, parallel to what is now the Panama Canal, and very dangerous, subject to pirate attacks.

The American fleet in the Caribbean was mainly composed of small vessels that connected ports in Cuba (Havana, Santiago, Matanzas), Puerto Rico (San Juan, Ponce), Santo Domingo Venezuela (Cumaná, La Guaira, Puerto Cabello, Coro, Maracaibo), the New Kingdom of Granada (Riohacha, Santa Marta, Cartagena), as well as Central American and Mexican ports. Cuba was an important island in the Atlantic-American connection since it became an area of commercial intermediation for the Spanish fleets and a centre for the meeting of other Creole and North European commercial interests. In addition, since the installation of an urban centre on the coast, it was a preferential area for the manufacture of ships. In 1629 Philip IV ordered "that the neighbours of the city of San Cristóbal de La Habana may enjoy the third rank of Manufacturers of these kingdoms, and that their ships be admitted in the fleets that go to the Indies in the place that will touch them, according to their seniority from the day they arrive at the ports of these kingdoms".[10] Apart from these inter-American fleets, special navies had been created to patrol the American coasts. Between 1620 and 1648 attacks on the Spanish fleets became common. Piracy, smuggling trade and commercial competition from other maritime nations, such as England, Holland, and France, threatened the Spanish Atlantic offensive.

The financing of the protection navies was underwritten through the tax of damages (*impuesto de Avería*), collected from merchants. The *Armada de Barlovento* or

[10] Recopilación de Leyes de los Reinos de Indias. Madrid, 1841, Ley XI, p. 41.

seno mexicano was created in 1635 for the security and defence of the ports of New Spain, especially to contain diverse attacks (Torres Ramírez 1981), acting as coastguard throughout the Caribbean Gulf. But the creation of this and other navies did not prevent attacks on the fleets of the Indies, as had already happened in 1628 by the Dutch fleet under the command of Admiral Piet Heyn in the Bay of Matanzas, Cuba.[11] Previously, the *Armada de la Mar del Sur* (1578–1740) had been created to protect the Viceroyalty of Peru and the South Pacific routes, but it was also used to transport silver from other important centres. The South Pacific route included some 4000 nautical miles from Tierra de Fuego (Cape Horn) to Central America (Puerto Perico, Panama) and from its base in El Callao (founded in 1537) the South Sea armada made stopovers in Trujillo and Paita, where they were joined by the so-called gold ship ("navío del oro") from Guayaquil (Pérez-Mallaina Bueno 1987).

The fleet transported the silver from Potosí, previously taken to El Callao from the port of Arica, as well as the wealth of the kingdom of Chile, which had arrived from Valparaíso. The South Sea Armada then returned to Peru with European merchandise, such as foreign linen, Andalusian wines, Mediterranean-type foodstuffs (oil, dried fruits, etc.), and mercury (quicksilver) for the silver mines. It is noteworthy that, at the time of the great navy crisis in Europe, due to the defeat of Philip II's *Felicísima Armada* off the coasts of England and Ireland, this American navy already had six galleons, whose tonnage had increased due to the large shipments of silver they were transporting from Lima to Panama. These ships were built in American shipyards, mainly in Guayaquil, and also on the Pacific coast of Central America (El Realejo, Nicoya, and Panama), and in Chile. For the construction of a ship it was necessary to take into account the peculiarities of navigation in the Pacific, where ships had to sail at the point of a bowline "navegar a punta de bolina" (sailing upwind) and the caulking material was not hemp as in Europe, but rather tow, which offered greater resistance to decay (León Sánchez 2009). The entire process of building and rigging a galleon took approximately 2 years. The standard model of these galleons was 500 tons with a keel of 30 *varas* (1 *vara* equals 835 mm), a beam of 13 *varas* and 10 *varas* of depth of hold. The keel/beam ratio was 2.3. The wood was of Guachapeli with the sides of the deck and the main chamber of oak (where the cannons of the largest calibre were located). The hull was caulked with white tow (*estopa*—coarse part of flax or hemp used in the manufacture of ropes and fabrics) and Castilian pitch, and the rest with black tow and American pitch. In 1588 the *Armada del Mar del Sur* had five galleons: *San Pedro y San Pablo* of 400 tons and 32 cannons; *San Andrés* of 300 tons and 30 cannons; *San Jerónimo* of 250 tons and 24 cannons; *San Francisco* of 350 tons and *Ntra Sra del Rosario* of 160 tons (Pérez-Mallaina Bueno 1987). The navigation of this *Armada del Mar del Sur* had to be synchronized with the fleet of galleons from Tierra Firme so that when they left Cadiz, the fleets that brought silver and other products from Chile (Valparaiso), Alto Peru (Arica), Peru (Callao), and Quito

[11] BNE, "Memoria de lo que robaron los holandeses de la flota de Nueva España, el año 1628", Mss 23,148/33.

(Guayaquil) would also do so, to converge in Panama at the same time that the Atlantic fleet reached Portobelo. In this way, a simple exchange of silver for manufactured goods would be made through the Camino de Cruces, between Portobelo and Panama City. This rarely happened because it was very difficult to carry out this synchronization, which is why much of this silver never reached Spain.

4 Fairs, Goods, and Returns

The trade of the Indies made the Crown pretend that the American economy would develop according to the needs of the metropolis, that is to say, as exporters of raw materials and precious metals. Spain, on the other hand, tried to supply the Indies with manufactured products, inhibiting any American industrial activity that could compete with that of the metropolis, although this did not really work in practice. However, by means of the system of galleons and fleets, the Hispanic Monarchy assured the maintenance of a navigation that conditioned the transatlantic traffic as well as protecting the fleets from the increasingly frequent attacks of its main European rivals (Holland, England, France). This did not prevent, however, that some American regions developed under the protection of foreign smuggling in certain historical moments, such as the Dutch smuggling in the Antilles and the northern area of Venezuela and Guayanas in the second half of the seventeenth century; the French case during the War of Succession to the Spanish crown; and, especially, the English participation through the ship of permission and seat of blacks in the treaties of 1713 (de Alsedo y Herrera 1740). Although the foreign trade in America is well studied, it is not yet fully known to what extent this smuggling and the English “Asiento” had an influence on the future of the Spanish fleets.

In America, upon the arrival of these fleets, large fairs were held in Veracruz, Cartagena de Indias, and Portobelo. Later, around 1720, the Jalapa fair was created. The internal network to supply production and commercial demand around these trade centres was very complex. European goods were controlled by large merchants and moved to the main distribution centres: Veracruz to Mexico, where they were stored, distributed and resold to the entire northern viceroyalty (Escamilla 2011). Cartagena de Indias supplied all of New Granada; from Portobelo, the galleons‘cargo crossed the Isthmus of Panama and in this city it was re-embarked on the Armada del Sur to the port of Callao, to be stored and distributed from Lima to the rest of South America (Vila Vilar 1982). The merchants’ profits at the traditional fairs held at the ports of destination of the fleet were immense, exceeding 400%. Then, in the mining centres and in the most remote places, prices increased even more, allowing profits of up to 1000% over the original value of the products arriving from Europe. In the American port cities, the fluidity between commercial activity and fleet preparations was highly dependent on the control that local merchants had over the fairs, as was the case of Portobelo, controlled by merchants from Lima and later by the so-called *peruleros* (García Fuentes 1997).

For the organization of the return voyage, or *tornaviaje*, both fleets and galleons met in Havana, where the escort ships awaited them and the return trip to Spain was undertaken. In the American ports, the task of organizing the returns was complex and any miscalculation could unleash tragedies at sea. When everything was ready, the water was made, the provisions for the return were loaded and the departure order was given. The ships were put back in position for the voyage. From Havana they headed for the Bahamas Channel, a threatening but necessary area to cross in order to connect with the trade winds according to the router of the pilot Alaminos, between Cuba and Florida (Varela Marcos 1992). The voyage of "tornaviaje" was even much more dangerous than the arrival at the American ports, because in addition to the risks of hurricanes and storms, there was the danger of pirate attacks and ambushes by other enemy fleets. This threat increased in line with the value of the cargo being transported: the royal treasure made up of silver from taxes and tributes collected, and remittances from merchants. Silver came to represent between 85 and 95 percent of the Indian shipments to the Peninsula until the contraction of such shipments began in the second decade of the seventeenth century. The cause of this contraction has been debated on many occasions, although it is true that the causes have not yet been fully established. But on board of these ships were also large quantities of other goods, pottery (which sometimes has been useful to identify the ships) artifacts, and various products, precious stones, often belonging to trousseaus and luggage (*ajuares y equipajes*), as well as multiple types of containers in which the products and goods were loaded, such as barrels, pipes, boxes, wineskins, etc., made of different materials including wood. One of the most numerous exports from the Peninsula to the American continent was quicksilver, necessary for the extraction of silver in the mines of New Spain, which represented a considerable increase in the wealth of the crown. This material came mostly from the Almadén mines. Other products exported to America were oil and wine, paper, iron, books, and fabrics. The export of luxury manufactures was used to produce profits both in the form of tariffs and sales, as well as a great deal of nautical equipment, food supplies, medicines, weapons, ammunition, and various other goods (Mena García 2004).

The navigation of the galleons to Tierra Firme was, at times, more dangerous than that of the fleets of New Spain. A memoir of 1654 describes the departure of the galleons from the bay of Cadiz, the captain ship leaving on June 2 of that year and the rest of the ships of the armada with five merchant ships departing the following day. Two galleons and the fleet of New Spain were dispatched, as well as some *pataches* that went with the galleons also to Portobelo, Cuba, and Margarita Island. With several ships the expedition reconnoitered the coast and sailed among the windward islands, arriving at Cartagena on July 12.[12] The return voyage was very dangerous and also had to overcome the problems derived from the state in which the ships could be found after the voyage, as described in the anecdote of the

[12] BNM, "Relación de viaje de una flota enviada por el rey Felipe IV desde Cádiz a Portobelo, 1654", MSS. 18,719/40.

galleon *Hercules*, which had “made the voyage from Spain with a lot of water and not being able to ensure the return with any work”, and *Santiago* “had a lot of carpentry and caulking work done and a new main tree brought from Spain”. When a ship could not be repaired, it could be sold in the port of destination and never returned to Spain, using its stores and supplies to arm another ship of the fleet that had lost its equipment and rigging. The anonymous author of this memoir, perhaps the Marquis Conde Alegre himself, commander of the galleons, states that he arrived at Portobelo on August 2. It was customary to await the arrival of the Peruvian navy, prior communication between the president of the *Casa de la Contratación* and the admiral of the navy so that upon the arrival of the galleons at Portobelo the treasure could be “lowered for shipment, as had been done since 57”.[13]

The author of this report complained, like other admirals of his time, of the continuous delays in all port activities related to the custody of the navies or communication with the authorities, who were not always willing to cooperate given the corruption that existed in the Indian institutions themselves and the long waits for the warning ships. The *navíos de aviso* were the only way to keep the *Casa de la Contratación* informed of any possible problem. The captain tried, in vain, to persuade the Count of Alba, Viceroy of Peru, and President Pedro Carrillo (sic) to order, in the shortest possible time, a dispatch so that the royal officials in Panama would send the treasure that was to return to Spain. Carrillo took a month to deliver the register with the memoirs of “what all those of the commerce of Peru had presented to his person”, and with that material the captain began to make the register for the return trip, finishing on September 18 and taking from the hands of the silver masters the different amounts that were destined for Spain including the part of the king’s treasure, the wealth of individuals and what was derived from the sale of some products (629, 676, and 38,400 pesos, respectively) in addition to records of 204,114 *pesos*, 176,114 *reales,* and 28,000 *pesos* in indigo. These sums were, in the captain’s opinion, “little silver from his majesty and none from individuals”, mainly due to the irregularity in the arrival of the galleons and that most of this silver flowed through other channels. In reality, this was a reflection of the increasing activity of the *peruleros* during the reign of Philip IV, which caused, among other things, the galleons to become more and more spaced out. This fleet was dispersed, the captain arriving at the coast of Cantabria on April 12, 1659. Apart from the delays and apparently a lack of confidence, there was the problem of insecurity on the return voyage, which is also described by the anonymous author of the memoir.

The corsair and pirate danger increased when reaching the archipelago of the Azores. Sometimes reinforcement warships were sent from the mainland to these islands to await the arrival of the fleets. From the Azores they would head for Portugal. Finally, the Spanish southwest was reached and finally to Sanlúcar, from where the galleons began to go up the Guadalquivir with difficulty to reach the river port of Seville. It was not uncommon for them to call at the Algarve, in southern Portugal, and at the coast of Ayamonte (Huelva, Spain) to unload contraband.

[13] BNM “Relación … .” (passim).

However, it was stipulated that no warning ships were to be sent to the Peninsula, so as not to alert the pirates, so the exact date of the fleets' return was almost never known in Spain. The first news of their arrival was to see them arrive at Sanlúcar. But this return route also ended in a dangerous funnel from the technical-maritime point of view: the mouth of the Guadalquivir River, due to the problems caused by the so-called *barra*, a mobile sand bank that caused many problems for the large ships to reach Seville. In addition, the Guadalquivir estuary was easily accessible from European ports, as was seen on more than one unfortunate occasion. Although the laws of the Spanish crown stipulated that fleets go up the Guadalquivir River to complete the registration of goods and silver at the *Casa de la Contratación* in Seville, this arm of river navigation became increasingly problematic as a result of the estuary's own geological evolution. This problem gave rise to a series of soundings of the river such as those carried out by Fernando de Villegas (1666), with a tool called *escandallo*; Pedro Fernández Navarrete, Captain Francisco Salom, Antonio Gaztañeta and several deputies from Sanlúcar (1702); Alberto Mienson and Miguel Sánchez Tamaraz aided by pilots and sailors with experience on the Guadalquivir bar (1720); and finally in 1722 by Manuel López Pintado. The intentions of these measurements of the flow of the Guadalquivir River were carried out in a context of rivalry between Seville and Cadiz to maintain or transfer, if necessary, the courts that supervised the trade of the Indies and the naval headquarters for the organization of the fleets. However, it was clear that with a draft oscillating on average between 5 and 7 m depending on whether the tide was high or low, the large-ship galleons had a very difficult time going up to Seville, so the Bay of Cadiz and the ports of Bonanza and Sanlúcar were favoured by a policy of rehabilitation of the organizational system of the fleets and galleons between 1680 and 1725 (Crespo Solana 1996; Márquez Carmona and Alonso Villalobos 2019). In fact, the Sanlúcar bar was one of the most dangerous areas for shipwrecks along with the Bahamas Channel and the coasts of Galicia and Northern Portugal.

The Crown was always afraid that American silver would be lost if other peninsular ports were opened to the *Carrera de las Indias* and it was more convenient to control it from a single terminal, which is why it favoured the interests of Seville, which became, thanks to the fleets, a centre of attraction for international migration, even referred to by foreign emigrants and travellers as the *Puerta del Oro* (Gateway to Gold). Its population grew from 45,000 inhabitants at the end of the fifteenth century to 130,000 at the beginning of the seventeenth century. But with time, and among other factors, the increase in the tonnage of ships made Seville a difficult port for the Indian trade, since it prevented ships from sailing up the Guadalquivir River. In 1680 it was decided that the galleons would leave and arrive in Cadiz, a port that had an appropriate bay to become the naval and military centre. But due to the competition between merchants from Seville and Cadiz, the naval aspects of the fleets were organized in Cadiz and the bureaucratic in Seville for several decades, sometimes producing strange administrative redundancies. In Seville the merchandise was unloaded, the silver was counted, the taxes were collected, the sailors were paid and the armament was returned to the arsenal, but in Cadiz all kinds of mercantile activities were carried out and the port functioned as an entrepot of ships and products destined for re-export. As a settlement base for many merchant communities of foreign origin, it also became an oligopsony of illegal silver merchants and a fairing centre of great logistical importance. Until the opening of the Suez Canal, Cadiz was the last stop in southern Europe before embarking on global navigation, which is why the large shipping companies called at this city.

5 Ships, Wrecks, and Another Avatar

At the economic level, the Iberian Peninsula acted as a provisional deposit of goods for Mexico (and for America in general) with some intermediate stopovers that served as local entrepôts (located in the Caribbean and the Antilles) where there were commission agents of very diverse origins and nationalities. This made it practically impossible for a large part of the gold and silver to reach the hands of the Crown, since there were traders who were the real financiers in these businesses. In this regard, studies have been carried out that analyse the arrival of large quantities of American silver to the North European markets. This fact poses a dilemma in relation to the cargoes of gold and silver on board the ships which, contrary to what has been said even in the legislations on the protection of the patrimony, belonged to individuals in a high proportion, as was the exemplary case that introduces this chapter: the fleet of Manuel de Velasco sunk at Rande and to which I referred to at the beginning of this article.

The internal American economy was related to important land connection nodes and auxiliary fleets. When fleets were delayed in ports, ships were faired and prepared for the new voyage. A very common problem was the poor condition of many ships while hibernating in American ports. It was common that the ships of the fleets of the Indies were already in very bad condition when making the voyage and having to wait a certain amount of time in the American ports, they were incapacitated for the return voyage. These accidents of "inhuman fortune" were very frequent, but no less so than the "imperfection" of the pilots and sailors in command of the fleets. In addition, studies on the dynamics of some historical shipwrecks show how the origin of these problems was, on occasions, in the frauds related to the construction of a ship, since it was common to certify less tonnage with the intention of creating an extra ship for smuggling and unregistered goods (Enríquez and Stapells 2006). The fraud in shipbuilding coupled with irregularities in the American port before the return voyage illustrate the narrative of so many other shipwrecks in American waters (Trejo Rivera 2003). This may also have encouraged the need to create shipyards and arsenals in America to supply the Spanish fleets. It seems that during the seventeenth century this circumstance was increasing, although in open competition with the Basque and Cantabrian shipyards from where most of the more important galleons of the *Carrera* still were supplied (Rodríguez Lorenzo 2017; Valdéz-Bubnov 2019).

Undoubtedly, the problem of preparing for fleet returns encouraged, among other things, the strengthening of shipbuilding in America. The map of American shipyards was closely related to the way in which American port enclaves were established for the arrival and departure of oceanic fleets and the daily business of fleets, navies, and internal flotillas in America. Although the first known ship built in America, *Santa Cruz*, was built in 1496 by Christopher Columbus himself, American shipbuilding reached its peak in the seventeenth century. Most of the ships destined for the fleets of the Indies originated in the Bay of Biscay in the sixteenth century. However, a growing shipbuilding activity developed in the Indies, almost at the same time as the American expansion, reaching a certain scale at the initiative of Cortés in 1519. During the second half of the seventeenth century, one third of the ships that made the *Carrera de Indias* were American. Outstanding shipyards were those of Havana, Veracruz, Cartagena de Indias, and Guayaquil. The latter was an important shipbuilding centre where the galleons of the Armada del Mar del Sur, which patrolled the Pacific coast from Peru to Panama to transport silver, were stationed. In the seventeenth century between 30 and 40 ships were built with private ship-owners being the first shipbuilding industry in the American Pacific, located in the Gulf and estuary of the Guayas River and Estero Salado on the Ecuadorian coast. In these shipyards the Galleons of the Navy of Núñez de Balboa were built in 1520 (Goldenberg 1976). Around 1560, local information is recorded about the timber that was collected in the mountains with mitayo Indians watched over by a superintendent (Clayton 1980; Laviana Cuetos 1984).

However, also in Seville, on the Guadalquivir River, there had been a high level of activity around the shipyards, in addition to an important shore carpentry activity in lower Andalusia, closely related to the transmission of knowledge from Portugal and the Mediterranean (González Cruz 2018). In Cadiz, from 1640 onwards the mercantile pressure and the needs derived from the *carena* of the increasing number of ships arriving in the Gulf of Cadiz gave rise to a process that culminated in the official transfer of the Contratación courts in 1717. The actions of foreign merchants in that city had a lot to do with this decision due to the control they had over some resources, such as salt, and their ability to relate to the local elites. But, undoubtedly, there were two main reasons that produced the definitive transfer of the courts of the Indies trade from Seville to Cadiz: the control that foreigners had over the American silver that arrived in the "returns" from the Indies and the need to build ships, galleons, and ships of the line, of greater tonnage and draft (calado) (Valdez-Bubnov 2018). This debate, evolved from the meetings of the reign of Philip II that gave rise to the shipbuilding treatises and the Ordinances, also determined the need to create coastal and riverside areas near the centres of timber supply related to the practice of storing pieces, stockpiling in a more systematic way than had been done since ancient times on the banks of ships by shipwrights (Gasch-Tomás et al. 2017).

In the *Carrera de Indias*, most of the ships were built by order of merchants who requested a license from the king for their own use, while the ships that served the Crown (the true "ships of state" of the time) were built by agreement between the king and private merchants who were in charge of organizing the entire construction process, from the collection of wood in the forests and its transfer to the shipyards to the design of the ship. The construction activity both on the banks of the

Guadalquivir and in the Bay of Cadiz became effervescent, although it could never compete with the construction of large galleons in Cantabria and the Basque Country, Lisbon, and other Portuguese coastal areas, in the Kingdom of Naples (then belonging to the Monarchy) and in America, especially in the second half of the seventeenth century. But apart from these two strategic areas for the preparations and organization of navies, many other shipbuilding areas were established in Portugal, coasts of Andalusia, Catalonia, and the Basque Country and Cantabria that competed with each other to contribute ships to the *Carrera de Indias* although with a great dynamic of transfer of knowledge and technologies between them (González Cruz 2018). These ships had a great variety of typologies and there are still important gaps since many of them were constituted as hybrids between two or three different schools or typologies of ships. One of these debates discusses the endurance of the use of caravels, protagonists of the first voyages to America, but which it was soon seen that they were not good for "discovering", as Christopher Columbus himself stated in his "Diary". In spite of this, they were used in the Atlantic trade during the sixteenth century. Pedro Menéndez de Avilés, for example, used them in the fleet he commanded as Captain General, and which he led to the viceroy of Peru, Andrés Hurtado de Mendoza, and which sailed from Sanlúcar de Barrameda in October 1555 with 78 merchant ships, 2 navy galleons, and three "large caravels". The caravel had been used mainly for navigation in the Mediterranean, as can be seen in a charter document of a caravel in Cadiz in August 1568 to carry "clothes and merchandise" (ropas y mercaderías) to Larache ("land of the Moors" sic).[14]

Later on, larger ships appeared, equipped with cannons and two castles (the one at the bow and the fortress at the stern) and could transport 150 sailors and 500 soldiers over short distances. But undoubtedly the novelty was the Galleon, even larger and much more heavily armed than the Nao, which would later become the spearhead of the Armada, although with important North European influences. Both the Nao and the Galleon were ships with a more rounded hull and three masts (mizzen, foremast, and mainmast). The former was a derivation of the Carraca with more artillery and the latter, a response to the Atlantic waves that the Naos could not easily overcome. Their artillery and navigational advantages were not very great in the Mediterranean, but they were in the new scenario that would soon become the most important. From the last decades of the sixteenth century, a debate was politicized around the regulations of the determination of the capacity, and size of the ships, producing also a disparity between shipbuilding treatises, laws of the crown (in boards and ordinances) and regional practice of naval architecture that was carried out in each territory, so that it is very difficult to identify a homogenization in Iberian shipbuilding. Furthermore, contrary to what has been said, most of the authors of the naval treatises of the period were not master builders, with the exception of Francisco Antonio Garrote (Apestegui 1984). García de Palacio was not (even

[14] AHPC Protocolo n° 1075, Cádiz, 20 of August, 1568, Freight contract of caravel "La Trinidad".

though he was in charge of the management of a couple of ships in El Realejo), nor was Tomé Cano.

As for the tonnage of the ships, between 1506 and 1525, the ships were usually about 100 tons. From 1524 onwards, ships ranged between 120 and 150 tons, and from 1548 onwards, those of 200 tons predominated, although there were larger ships of 300, 400, and even 600 tons, however, those larger than 220 tons were few. By Royal Decree of May 5, 1557 “ships over 400 tons were not allowed” because of the problems that could arise when passing the Sanlúcar bar. This was soon corrected and during the following two centuries warships moved between 600 and 2000 tons (Chaunu and Chaunu 1977). At that time, the Atlantic fleet had the best techniques and the most recent advances in navigation; their plans, design and construction of Naos and Galleons were a jealously guarded secret. So much so that it has not reached our days, as demonstrated by the fact that none of the replicas made on the occasion of the 500th anniversary of the discovery of America managed to match the times of Columbus.

This system of the *Carrera de Indias* became slower and slower. In the seventeenth century, the round trip from Spain to Mexico took a year, since it was necessary to take into account the waiting time due to the formation of the fleets. With many ups and downs and in spite of the criticisms received by historiography and contemporaries, this system survived until 1778 when the *Reglamento de Libre Comercio* was issued, although by 1740 the fleet of the *Galeones de Tierra Firme* had already been suppressed, and the registration ships and the privileged trading companies were more favoured. Nevertheless, and contrary to what has been said on some occasions, the transoceanic voyages of the fleets and galleons were practiced regularly although with ups and downs between 1596 and 1622 (Lynch 1986) and then from 1654, according to the testimony of the captain of sea and war (Capitán de mar y Guerra), a native of Seville, Antonio Garrote.[15] The fleets sailed every 2 years as was customary, according to the rules of the monopoly. In 1621 the navy of Thomas de Maspuru left with the fleet in charge of Juan Benavides and that of Tierra Firme with Juan de Florez Ravanal. In 1622 another fleet under Fernando de Sousa, the navy of the Marquis of Cadereitas and the galleons under Juan de Camorán, returned to Spain with the treasure in 1623. The 1620s were replete with maritime disasters exemplified by the sinking of one of the ships of the Tierra Firme fleet, the *Nuestra Señora de Atocha,* in the same year of 1622 in the Florida Keys. This ship had been built in Havana while her companion in misfortune, the *Santa Margarita*, had been built in Cádiz (Alcalá-Zamora y Queipo de Llano 2008).

Apart from these irregularities, the navigation of the Carrera was also subject to accidents at sea and to human ups and downs such as the death of the people in charge of the fleets or other difficulties that caused the lengthening of the wintering periods, a very common contingency. This was the case of Thomas de Mazpuru’s Armada of 1628 “that did not come this year due to wintering and came on Saturday,

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[15] BNM, “Manifiesto al Rey y al Consejo de Indias del Capitán de mar y guerra, Bartolomé Antonio Garrote, en que demuestra que las Armadas y flotas de Nueva España y Tierra Firme han salido de estos reinos para América todos los años desde 1580 a 1699”, Mss. 12,633, fols. 192–214.

April 7, 1629"; or that of Carlos de Ibarra's armada of 1636 that accompanied two fleets for New Spain in charge of Martin de Vallecillas and Juan de Vega Bazan, since "due to the death of the former, both fleets came in charge of the latter" together with the galleons commanded by Luis Fernandez de Cordoba. Other cases warn about the offensive dangers of enemy fleets. In 1637 the armada of Carlos de Ibarra, Marquis of Caracena, had problems in its return "for fighting with the Dutch enemy in sight of Havana without being able to capture him, he went to winter in New Spain and could not come to these kingdoms in the year 1638 and came from said provinces of New Spain in the year 1639 with the fleet of General Martin de Orbea in the month of July".[16] The seventeenth century would witness more coordination problems in the ports and along the routes that caused the fleets to not always be able to sail on the official route or that unexpected accidents occurred. The shipwreck is also a producer of wonders and findings such as the "mysterious island" related to the *saca de la plata* activities of the admiralty *Nuestra Señora de las Maravillas* in 1657.[17] These findings (which have nothing to do with R. L. Stevenson's novel) contributed to the development of a strategy by the Spanish and American authorities when it came to intervening in ships that had been wrecked at sea for various reasons. The salvors of shipwrecks received very detailed instructions for diving the sunken ships and recovering the valuable cargo, which they had to inventory, "close with chains and padlocks" and put in a safe place (Téllez Alarcia 2006).[18]

The organization of the fleets and galleons began to be spaced out after 1656, although fleets departed in 1656, 1658, 1660, 1662, 1665, and 1666 (Serrano Mangas 1989). Subsequently, the preparations continued, although the number of merchant ships decreased, a problem that would later lead to the introduction of ships of foreign manufacture and provenance, although the sale and purchase of ships had been common since the sixteenth century (Rodríguez Lorenzo 2016). Since 1645, the shipment of silver and other merchandise experienced a notable decrease, and the tons of ships were increasingly complemented with European manufactured goods. This circumstance produced that the American silver passed directly from the holds of the Spanish ships to the ships of English, French, and Dutch flags, which refueled in the Bay of Cadiz waiting for those valuable returns (Serrano Mangas 1991). Undoubtedly, the Spanish crown itself encouraged bilateral diplomatic agreements with the states and trading companies of Northern Europe, especially after the Treaty of Utrecht, as happened in the case of the peace and trade agreements with England and with the States General of Holland that caused a high transfer of silver to Dutch and English ships in the port of Puntales in Cadiz (Crespo Solana 2000, 2008). This was a hot topic in the criticisms of the Seventeenth Century Spanish *arbitristas*, statesmen who saw the causes in a problem of national failure: the poverty of industry and the decline of the population.

[16] AGI, Contaduría, 570: Relaciones y registros de flotas y galeones, e islas de Barlovento.

[17] AGI, Indiferente General, 2699; AGI, Catálogo de mapas y planos de Santo Domingo, p. 90, n° 89 "Isla Misteriosa hallada por Simón Zacarías entre Cuba y Cartagena de Indias, cerca de la isla de Pinos en 18° y 50°".

[18] AGI, Indiferente General 2799.

During the War of the Spanish Succession, the Spanish trade with the American ports suffered briefly, to rebound with great strength starting with the fleet of 1711. The fleet of 1711, organized by the minister José Patiño, sailed from Cadiz under the command of Andrés de Arriola and, in addition to 1596.85 tons of merchandise, carried the Duke of Linares, recently appointed viceroy of New Spain. On its return, several ships were separated due to the storms that hit the fleet when leaving Havana in 1713, and the ships arrived at Cadiz and Faro, in Portugal, under the command of Pedro de Ribera, due to Arriola's death in Veracruz.[19]

During the war itself, both the trade of the *Carrera de Indias* and the system of fleets and galleons itself was greatly diminished not only by the irregularity in maintaining the maritime line but also by the insecurity of the sea due to episodes of war that led to the destruction of some of the best ships of the fleets. The episode of the Battle of Baru in which the Galleon *San José* sank in June 1708 is epic. The attack on this fleet was also due to a miscalculation or negligence of its commanding general, the Count of Casa Alegre. What is certain is that the loss of this galleon built in 1698 by Duke Arístides Eslava and in the shipyard of Mapil in Aginaga (Guipúzcoa) and by Pedro de Aróstegui, with the specifications of Francisco Antonio Garrote would be an interesting case of archaeological study to determine if it had influences of Antonio Gaztañeta who would later become the most important shipbuilder of the first half of the eighteenth century in Spain. In fact, he was the author of important shipbuilding works that were official references for the Spanish Crown almost by the 1750s, such as the *Proporción de las medidas arregladas a la construcción de un bajel de guerra de setenta codos de quilla*, published in 1712, and others. Throughout the eighteenth century the fleets were regularized, although the galleon voyages decreased until they disappeared in 1740. Since the end of the war, the system of the *Carrera de Indias* faced reforms and reorganizations, the most important being the introduction of a law that allowed the "loose vessels", recognized in the *Real Proyecto de Flotas y Galeones* (Royal Project of Fleets and Galleons) of 1720. But it was between 1739 and 1754 when the War of Jenkins' Ear, in the context of the Austrian succession, caused the effective establishment of the registry system, and the creation of privileged trading companies for the Americas (García-Baquero González 1988). The *Carrera de Indias* had developed in parallel to the emergence of other economies both in America and in the Atlantic-European framework in general, in the context of a great global convergence developed by a triangular trade that imposed a determining spatial logistics in the Atlantic world, with consequences even today.

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[19] AGI, Contratación, 1272, 1273. Registros de navíos.

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Chapter 4
Iberian Ships of the Early Modern Period

Filipe Castro, Marijo Gauthier-Bérubé, and Miguel Martins

Abstract At the cultural convergence of three different worlds, the Atlantic, the Baltic, and the Mediterranean, Spain, and Portugal played an important role in the Renaissance technical revolution. Both countries developed new types of watercraft during this period and adopted new navigation techniques that allowed them to venture further away from the Iberian Peninsula. Thousands of books have been written about the Renaissance and the European expansion, but the ships that made the European voyages possible are still largely unknown to us. This short chapter is a contribution to a better understanding of the origins of Iberian shipbuilding traditions.

1 Introduction

As explained by Marcel Pujol in Chap. 6 of this book, ship shapes and sizes varied with their uses and their maritime environments. Their development happened in a cultural setting that was both progressive in its attitudes and traditional in its business structures. Technological innovation shaped new ships, mixing traditions to produce a continuous stream of ideas and construction practices (Oliveira 1995).

The world of the fifteenth and sixteenth centuries changed drastically, and at a fast pace. The post-medieval world was volatile. Its power superstructures were affected by the development of rural capitalism, urbanism, industry, commerce, banking, diplomacy, intelligence agencies, and war machines and theories. Both middle and upper urban classes understood the value of knowledge and like everything else in Europe, ship conception and construction changed from parochial to cosmopolitan paradigms.

The original version of this chapter was revised. The correction to this chapter is available at https://doi.org/10.1007/978-3-030-86460-6_14

F. Castro (✉) · M. Martins
Universidade Nova de Lisboa (UNLA), Lisbon, Portugal
e-mail: fcastro@fcsh.unl.pt

M. Gauthier-Bérubé
Texas A&M University (TAMU), College Station, USA

A. Crespo Solana et al. (eds.), *Heritage and the Sea*,
https://doi.org/10.1007/978-3-030-86460-6_4

The study of the complex relations between tradition and innovation is exciting because they are difficult to map and understand in such a dynamic and porous context.

The ships of the Portuguese age of discoveries can be considered hybrids, as they can be described as Mediterranean ships with Atlantic reinforcements. But ships are also the result of the shipwright‘s taste and knowledge, the availability of building materials, and the ship owner's perceptions of quality.

The study of Iberian ships requires a definition of these ships and a comparison with their contemporary European types and models. Preceding the in-depth study presented in Chap. 6 we want to quickly address the probable origins and influences on Portuguese shipbuilding since the first millennium BCE and up to the fifteenth and sixteenth centuries and suggest a theoretical approach to improve our understanding of shipbuilding cultural evolution.

2 Origins of Portuguese Ship Construction for the Atlantic

Phoenicians, Greeks, Carthaginians, Romans, Suevi, Visigoths, Vandals, and Arabs, among other visitors and settlers, all left their influences in the Iberian Peninsula's architecture, language, agriculture, religious beliefs, and many other cultural and technological aspects, including its shipbuilding traditions. Phoenician merchants visited the Iberian Peninsula in the first millennium BCE and probably brought writing, the potter's wheel, and iron technology to this end of the known world (Arruda 1999). They probably arrived on shell-based built vessels, likely built with large pegged mortises and tenon joints, similar to the ones found on the 1300 BCE Uluburun shipwreck (Pulak 2002). They were followed by Greek sailors and settlers, probably traveling on boats with their planks sewn together (Polzer 2010). Carthaginians and Romans also sailed into the Iberian Peninsula, probably on ships built by joining the planks together with small-pegged mortise-and-tenon joints. The archaeological record in Portugal is scarce. There are news of a Roman shipwreck looted and they destroyed by dredges at the mouth of the Arade River (Castro 2006), and ceramic finds suggest the existence of another two shipwrecks from the Roman period in Peniche (Blot and Bombico 2013) and Esposende (Morais et al. 2013).

In the first decades of the first century CE, the Greek geographer Strabo mentioned rafts, skin craft, and dugout canoes in the Iberian Peninsula. We know that the latter were extensively used at least from the end of the first millennium BC until the modern age, being documented on the Bay of Santander as late as the sixteenth century (Casado Soto 1995). Five dugouts were found on the margins of Lima River, in the north of Portugal, between 1985 and 2003. Their dates span from second or first centuries BCE to tenth or eleventh centuries CE (Alves 1986; Belo 2003; Alves and Rieth 2007).

The ships of the peoples that lived in the Iberian Peninsula in the five centuries that followed the sack of Rome, in the early fifth century, are not known to us. Visigoths, Byzantines, Arabs, Franks, and northern migrants successively occupied the Peninsula and traded, waged war, and transported people and goods on a variety of watercraft. We have only a few written references to watercraft from this period (Pico 1963), and perhaps even less surviving iconography.

The Arab occupation probably kept most of the habits and structures intact. Arabs were shipbuilders and fishermen and must have built and used vessels to sail along the coasts and into the Atlantic. They sailed their galleys to Galicia, as mentioned in the *Cronica Compostellana* (Filgueiras 1989).

Portugal was carved out of the Iberian Peninsula from the twelfth century onwards through complex historical reasons and its territory does not encompass a single cultural horizon. The north perhaps has obvious cultural and geographic affinities with Galicia, the centre with Castilla, and the south with Andalucía. Traditional watercraft illustrates the cultural divisions of the Portuguese territory. The north – as already mentioned by Pujol in the previous chapter – seems to have been in more intense contact with the Cantabrian region, the south with the Mediterranean, and the centre seems to have formed during the late middle age as a melting pot of European invaders' ideas and Arab residents' practices and gestures.

3 The Germanic Influence in the Fifth Century

Galicia has a clear northern connection. For instance, today's *dornas* are lapstrakes, built under a clear northern influence (Alonso Romero 1991), and so are the bottom based *barcos rabelos* from the Douro River, built with flush laid planks on the bottom and lapstrake sides, in the manner of the Hanseatic League cogs (Filgueiras 1992).

Octavio Lixa Filgueiras suggested that some of the craft that could be found north of the Douro River region was built with northern influence, perhaps from the Germanic Suevi people, which invaded the Iberian Peninsula between CE 407 and 409, together with other Germanic tribes, the Vandals and Alans (Filgueiras 1979). The Portuguese coast is difficult, however, with few good bays or natural harbours, and it is possible to guess southern cultural influences in the *saveiros* from the Aveiro delta, which seem to be evolved plank canoes and present incredible similarities the Middle Eastern model from Ur, dated to the late third millennium BCE, as famously suggested by Octavio Lixa Filgueiras (1980).

Lapstrake construction may have been utilized in the late middle ages along the coast south of Aveiro, although the only evidence is a small frame found on the now silted bay of Alfeizerão (Alves et al. 2005), already mentioned by Pujol, and a larger frame, dated to the late sixteenth or 17th centuries, found at the mouth of the Arade River and possibly belonging to a lapstrake exposed by dredging works in the 1970s (Castro 2006).

4 North African Influence in the Eighth Century

The Muslim chieftains that composed most of southern Iberia in the seventh century brought visitors from the north of Europe as part of the ongoing movement of the crusades (Le Goff 2000). Arabs have also been great shipbuilders and may have used frame-based vessels since perhaps as early as the eighth century. The hypothesis that they were the developers of this shipbuilding tradition cannot, at this time, be excluded.

In the late eighth century, Al-Jahiz, the author of the *Book of the Animals*, mentions an Umayyad governor of Iraq named al-Haggag, who died in CE 714, and is reputed to have built the first vessels "nailed and caulked". Other Arab documents, from the tenth century onwards, mention the construction of vessels built with planks nailed to the frames as opposed to the Indian Ocean and Red Sea vessels, in which the planks were sewn together (Darmoul 1985; Harpster 2005). Muslims were an important naval power in the Mediterranean; it is logical to assume that the Arab world was another important source of influence on Iberian shipbuilders. Arab warships had helped the Arab conquest in the eighth century and later, their galleys fought Viking invaders, and sacked coastal villages regularly since the Christian leaders had started the northern push against Muslim rule we call the *Reconquista* (Filgueiras 1989).

A number of shipwrecks found on the coast of present-day Israel, namely the Dor D, Dor 2001/01, and Tantura A (all dated to the sixth century), Tantura B (ninth century), and Tantura F (tenth century), are the earliest known examples of this skeleton-based tradition (Wachsmann and Kahanov 1997; Royal and Kahonov 2000; Kahanov and Royal 2001; Barkai and Kahanov 2007). Unfortunately, not all these shipwrecks have yet been fully recovered, disassembled, and analysed, and it is therefore impossible to state with certainty whether they were constructed in a purely skeleton-first way, or whether there are any edge fastenings in the planking of the lower hull. Be it as it may, all the evidence mentioned above seem to suggest a Middle Eastern or Arab origin for the skeleton-based shipbuilding tradition, perhaps as the result for the lack of proper timber, or for the lack of labour trained in mortise-and-tenon joints construction.

Another group of shipwrecks found on the southern coast of France, namely the Agay A, Agay B, Batéguier, and Estéou shipwrecks (all dated to the tenth century), also suggests that Arab ships of this period were built by the frame-based method (Ximenes 1976; Jézégou et al. 1997). The *Reconquista* lasted more than ten generations, from the twelfth to the fifteenth century, and encompassed periods of peace and cooperation as well as alliances and substantial sharing of ideas and cultural traits. Moreover, after the conquest of the Peninsula by Christian kings, a part of the Arab population was absorbed and converted into Christianity.

Christianized Arabs – or *moçarabes*, as they were known – almost certainly went on building boats and ships under the new Christian rulers. Being absorbed into a bigger population group does not mean total annihilation of previous knowledge; Christianized Arabs did not stop using their ways of building ships, blending their skills to newcomers. As an example, the Christians that settled in the south of the Iberian Peninsula adopted Arab values, practices, and vocabulary. For instance, the Portuguese word for tail frame, *almogama*, literally translates as "meeting point" in Arabic. The fact that Portuguese shipwrights adopted an Arab word suggests the existence of two closely integrated cultures within the shipbuilding profession. This is further substantiated by the writings of Father Fernando Oliveira. Oliveira wrote about his visits to harbours and shipyards of Spain, France, Italy, England, and "some in the lands of the Moors". He wrote about how he "practiced with their [the Moors] carpenters, and learning their styles, and carpentry customs, and construction traditions". Known for his candour, Oliveira mentioned the Maghreb harbours and shipyards together with the Italian and the Spanish counterparts without expressing any particular criticism. It is very likely that shipbuilding in the Maghreb was as good and sophisticated as in any other major seafaring country of the time (Oliveira 1995).

5 Mediterranean Influence: The Genoese between the 12th and 16th Centuries

A Mediterranean influence on Iberian shipbuilding is documented as early as the twelfth century, when bishop Gelmirez of Santiago de Compostela hired Italian shipwrights from Pisa to build and operate a fleet of galleys for the protection of the Galician coast, often attacked by Arab parties (Filgueiras 1989). During the thirteenth century Genoese ships began visiting the coast of the Bay of Biscay and setting up intermediate trading posts for their commercial enterprise in the north Atlantic. Already trading with Muslim Seville, the Genoese established a permanent presence in the city soon after it was conquered by King Alfonso X, in 1248. By the second half of the fifteenth century the Genoese community in Seville had grown quite large (Pike 1966).

Perhaps more importantly, the presence of Italian merchants and bankers in Spanish and Portuguese courts and in prominent cities is well documented in the fifteenth and sixteenth centuries (Coelho and Battelli 1934; Lowe 2000). More than one century of scholarship attests this presence, as well as the intense cultural interchange between Portugal, Castile, and Rome, Florence, Venice, Pisa, Genoa, among other Italian cities and regions. Another major player in the Iberian expansion into the Atlantic was the kingdom of Aragon, which was part of the Mediterranean cultural world.

The contact between the Iberian crowns and merchants, and Italian cities is clearly illustrated in the roles of individuals such as Lanzaroto Malocello, Niccoloso da Recco, Angiolilo del Tegghia de' Corbizzi, Cristoforo Colombo, or Amerigo Vespucci. In the first part of the fifteenth century Portugal's Prince D. Henrique contracted the services of Italians such as Antoniotto Usodimare and Alvise Cadamosto to sail his caravels down the coast of Africa (de Albuquerque 1994). Colombo himself, allegedly came to Lisbon to join his brother in the 1470s, married a Portuguese lady, and sailed both Portuguese and Castilian ships before engaging in his attempt to cross the Atlantic Ocean.

Contacts with Italian navigators and shipwrights are relatively well studied and continued into the fifteenth and sixteenth centuries and may have intensified under the Habsburg rule. In February 1513, Pantaleone Queirolo, a shipwright from the small village of Varazze, appears to have left his homeland in Italy for Portugal with a group of shipwrights contracted to construct and operate galleys for the king of Portugal (Viterbo 1988; Ciciliot 2000).

It looks like Spanish and Portuguese shipwrights started building ships in the Mediterranean way, by using moulds and ribbands to obtain the shape of the hull, and then pre-designing the frames based on a midship frame mould and a system of reduction scales that progressively narrowed and raised the turn of the bilge points on each pre-designed frame.

We know from late sixteenth century shipbuilding treatises and archaeological excavations that both Portuguese and Spanish ships were built in this way, at least since the late fifteenth century, but probably considerably earlier. The Aveiro A, Cais do Sodré, Highbourne Cay, and Molasses Reef shipwrecks seem to share a certain number of characteristics – Eric Rieth's architectural signatures – that seem to be common to the Peninsula Atlantic ships, from the Basque country to the Strait of Gibraltar. In the second half of the sixteenth century, some shipbuilding treatises explain how to obtain, beforehand, a good and functional turn of the bilge line, using one of a small number of geometric algorithms to generate the curves of the vertical and horizontal projection of the turn of the bilge line (Anderson 1925; Bellabarba 1993, 1996; Rieth 1996; Bondioli 2003). This method prevailed in the Mediterranean until the twentieth century, perhaps because it presented two major advantages: firstly, because it was non-graphic and could be applied to each one of the pre-designed frames to mount over the ship's keel; and secondly because it was simple and could be applied with success even if the shipwright did not understand its geometric foundations (Castro 2007).

Moreover, circumstantial evidence, such as the units of measure and the geometric algorithms used in the shaping of the ship's hulls, indicate a close relationship between Iberian and Italian shipwrights. By the sixteenth century Portuguese shipwrights used the *goa* (77 cm) and the *palmo de goa* (25.67 cm) as units of length in their shipyards. Both these units have a parallel in Genoese units of measure (Barker 1998; Ciciliot 1998).

5.1 A Second Wave of Northern Influence in the Fourteenth Century

At the dawn of the Renaissance the Italian influence in Portuguese shipbuilding must have been rather important, but by no means unique. The Portuguese and some of the Spanish crowns traded with the Baltic Sea at least from the fourteenth century, exchanging cereals, metals, and textiles for salt, cork, olive oil, wine, and wool. In 1430 permanent commercial relations were established between Lisbon and Danzig, and there is evidence that Portuguese merchants bought vessels in the north, from Galician, Basque or British origins (de Albuquerque 1994).

Several shipwrecks from this period – for instance Highbourne Cay, *San Juan*, Newport, Western Ledge Reef Shipwreck – have mast steps that show a northern influence when compared with the Mediterranean mast steps of similar vessels (Rieth 1998). Similarly, the angular timbers possibly used to fasten the keel to the stem and sternposts in Portuguese ships, known as *couces* (*de proa* and *de popa*), have a parallel in the northern construction, in the *hooks* of the cogs and cog-like vessels. A third interesting feature may be typical of the Iberian Peninsula: rectangular or dovetail joints in the connections between floor timbers and first futtocks have been recorded in several Iberian vessels (Oertling 1989, 2001, 2004). These scarfs differ from the traditional Mediterranean hooked scarfs recorded in shipwrecks within the region, such as the early fourteenth century *Culip VI*, the sixteenth century Ottoman shipwreck of *Yassıada* or the late seventeenth century shipwreck *Sardinaux* (Rieth 1998). However, dovetail joints between floor timbers and first futtocks have been recorded in a growing number of northern shipwrecks, such as the Cattewater, B&W 7, or the Princes Channel shipwrecks (Redknap 1984; Lemée 2006; Auer and Firth 2007).

6 Conclusion

Positioned between the Mediterranean and the North Atlantic and Baltic maritime worlds, the Iberian Peninsula developed a rich and diverse collection of watercraft, each type suited for its intended purpose, resulting from the local natural resources and shipbuilding traditions, the availability of imported materials, and the influence of external contacts. During the Middle Ages hundreds of types of ships and boats were referred in documents. In the nineteenth century Admiral Quirino da Fonseca has listed 167 types in Portugal alone (da Fonseca 1915). This effervescence of types is rooted into this interminglement of different influences from northern Europe to the Arabic peninsula. The development of Portugal shipbuilding industry, or any shipbuilding tradition for that matter, should not be understood as an isolated event.

If a profound and determinant Italian influence in Portuguese shipbuilding is beyond discussion in the late Middle Ages, the identification and description of non-Italian traits in Portuguese watercraft remains a difficult task, given the scarcity of archaeological evidence. Diffusionism does not seem to be a good enough model to explain how new solutions were adopted and adapted in new paces. A lot of traits found on watercraft structures seem to result from a mix of new and old ideas, and when we consider the use of geometric algorithms to obtain repeatable hull shapes it becomes evident that these methods have travelled throughout the Mediterranean as practical recipes, rather than as well-understood geometric solutions.

Most archaeologists accept therefore, even if they seldom admit it in these terms, a Darwinian-like evolutionary model to explain change in the way ships and boats were conceived and built through time: good recipes adapted to new challenges and survived. Together with this slow and largely random evolution (based on taste, knowledge transfer processes, and availability of materials), a certain amount of radical innovation, driven by new intellectual trends, is commonly accepted, namely during the consolidation of the modern state, in the fifteenth century, with the development of royal shipyards.

For this reason, perhaps, a better evolutionary model to explain the development of new watercraft during Medieval and Renaissance would be Niles Eldredge and Stephan J. Gould's idea (1972) of punctuated equilibrium. This model, applicated to shipbuilding, postulates a slow and random evolution of ship shapes and rigging arrangements, punctuated with radical modifications established by law in the royal shipyards. In other words, to the constant diversification of ship types of the medieval period, each model surviving and adapting to the needs of its socio-economic environment, the development of a state sponsored shipbuilding industry added a stream of new ideas and inventions, often imposed by scholars a world outside the shipwright's own. All ships are an answer to a particular set of questions, considered all the restrictions of the time and place. The final result is a combination of skill, knowledge, and taste of the shipwright, and cost and availability of the necessary materials.

Following this line of reasoning, the amazing diversity of solutions that this process generates can be tentatively organized in taxonomic groups, according to common traits found in geographical areas and time periods. A certain amount of convergence, however, must be considered, mostly after the consolidation of the modern state, with the (re)appearance of highly organized naval shipyards such as the Venetian or the Portuguese ones. After the fifteenth century European oceangoing shipbuilding, as well as war craft shipbuilding, saw a continuous convergent trend towards standardization, driven by the central political powers at play. Convergence became the norm between all maritime powers, through adoption of traits perceived as functional, and of each vessel model – galleys, short sea trading vessels, long sea merchantmen, and even certain types of small craft such as caravels – looked increasingly like its neighbours throughout the late fifteenth and the sixteenth centuries.

For this reason, perhaps an even better model to explain shipbuilding evolution can be Richard Dawkins' *memetics* (1976), as his *meme* theory is sometimes referred to. The *meme* concept, loosely defined by Dawkins as a unit of cultural transmission, allows us to imagine a finer and more complex system in which certain ideas, concepts, or solutions can be considered cultural units susceptible of being created and passed along (replicated), either intact or transformed. In this particular case, *memes* can be singularly helpful to frame the process by which we hypothesize how characteristics observed in Portuguese ships were imported from the Mediterranean, from the north of Europe, or sometimes developed in-house. These *memes* are the same thing that Ole Crumlin-Pedersen and Eric Rieth have called respectively 'fingerprints' and 'architectural signatures' (Crumlin-Pedersen 1991; Rieth 1998). As mentioned above, Oertling was the first to point out these *memes* (Oertling 1989, 2001, 2004).

A growing number of shipwrecks excavated and published in the last two decades has allowed a better understanding of Oertling's original list of *memes*, and the definition of potential areas of use of these. His 2001 table is presented below. It was modified in 2004 (Oertling 2004), and reduced to eleven traits, since the

Table 4.1 Thomas Oertling 2001 list of architectural signatures

Preassembled Central Frames	A given number of central frames, assembled before they were set up on the keel, whose futtocks are joined to the floor with a dovetail mortise and tenon, and transverse treenails and nails.
Planking nails and treenails	The carvel planking is fastened with a combination of nails and treenails joining plank and frame. The nails are at the plank edge on the frame centerline and the treenails alternate across the centerline of the frame.
Sternpost scarfed to keel knee	The aft end of the keel is a naturally grown knee whose upper arm is scarfed to the sternpost.
Stern deadwood knee	A single piece deadwood knee timber sits on top of the keel knee. This timber reinforces the juncture of the sternpost and keel, provides a surface for fastening the lower hull planks and is the base for the aftermost Y-shaped frames
Y-timbers tabbed to deadwood	The stern Y-timbers are tabbed into the deadwood knee (the tabs supported the timbers until the planking was added).
Keelson notched over floors	The keelson is notched over the tops of the floor timbers.
Maststep is expanded keelson	The mast step is an expanded portion of the keelson, part of which is cut away to seat the ship's pump.
Butresses and stringers	The mast step is supported by buttresses and bilge stringers.
Ceiling / filler planks	Ceiling planking extends just above the ends of the floor timbers where the last ceiling plank is notched to accept the short transverse filler planks.
Rigging chain assemblies	The ships have as part of their standing rigging a teardrop-shaped iron strop to accept a heart block or deadeye which is attached to 2–3 lengths of chain and the last link through an eyebolt.
Flat transom	Flat transoms widening the deck abaft and pushing the midship frame forward.
Carved garboard	The garboard is carved from an extra thick plank.

archaeological record did not suggest that the garboards carved from a single plank were typical in the Iberian shipbuilding traditions (Table 4.1).

We have revisited Oertling's seminal work and reanalysed the traits he assigned to the Iberian shipbuilding tradition. The following are the results of our analysis.

6.1 Flush Laid Planking

This seems to be the rule in the Iberian Peninsula, at least from the beginning of the fifteenth century, except for the Basque country, where lapstrake was probably common during the early to mid-fifteenth century, as shown in the Barceloneta 1 (c. 1425) and Urbieta (c. 1450) shipwrecks, for example.

6.2 Preassembled Central Frames

This trait seems to be common in Iberian ships, although neither dovetail scarfs and treenails and iron nails are always associated with dovetail scarfs. As described in sixteenth-century technical texts, placing a certain number of pre-designed frames on the keel seems to have been the canonical way of building ships, not only in the Iberian Peninsula. After laying the keel and posts, shipwrights assembled a certain number of central frames, and fastened them to the keel. The bow and stern shapes were often obtained with ribbands. In some archaeological examples, such as the Culip 6 (c. 1350), Aveiro A (c. 1475), Cais do Sodré (c. 1500), and Pepper Wreck (lost 1606), the frames are numbered and have construction marks that suggest a particular non-graphic way of pre-designing them (Rieth 1996).

6.3 Dovetail Scarfs

Dovetail scarfs were found on shipwrecks from the Mediterranean, Iberian Peninsula, and North Atlantic. There is a prevalence of the use of trapezoidal (dovetail) scarfs on Iberian ships, such as the Aveiro A (c.1475), Cais do Sodré (c. 1500), Molasses Reef and Highbourne Cay (c. 1525), Emanuel Point 1 (lost 1559), Belinho 1 (c. 1550), *San Juan* (lost 1565), Western Ledge (c. 1575), Angra F (c. 1600), *San Diego* (lost 1600), and Green Cabin (lost 1618), to cite just a few examples, and shipwrecks like the Pepper Wreck (lost 1606) or *N. S. de Atocha* (lost 1622) – and perhaps *Santa Margarita* (lost 1622) – had square shaped scarfs. There are, however, dovetail scarfs in ships built in the north, like the Princes Channel (c. 1575) and B&W7 (c. 1600) shipwrecks, and this type of scarfs are also mentioned in Mediterranean shipwrecks, such as Calvi 1 (c. 1575) and *Lomellina* (lost 1516).

6.4 Floor/Futtock Fasteners

The fasteners used in the Iberian Peninsula seem to follow a pattern, with treenails or a combination of nails and treenails on the north coast, and iron nails with square shanks on the west and southern coasts.

6.5 Planking Nails and Treenails

Again, the use of nails and treenails seems to be only valid on the northern coast of the Iberian Peninsula. Ships built on the western and southern coasts seem to have been assembled exclusively with square shanked iron nails.

6.6 Sternpost Scarfed to Stern Knee

This seems to have been a common practice in the Iberian Peninsula. It was observed in most shipwrecks where this portion of the hull was preserved or recorded. It was found on the Corpo Santo (c. 1400), Aveiro F (c. 1425), Aveiro A (c. 1475), Studland Bay (c. 1525), Belinho 1 (c. 1550), *San Esteban* (lost 1554), *San Juan* (lost 1565), Western Ledge (c. 1575), Esposende 1 (c. 1600), Angra B1 and Angra D (c. 1600), *San Diego* (lost 1600), and Fuxa (c. 1610). In the Mediterranean, *Lomellina* (lost 1516) and Calvi 1 (c. 1575) seem to have keels ending with a natural curve and overlaying knee timbers.

6.7 Stern Deadwood Knee

Knee timbers overlaying the upwards stern knee seem to have been a common practice in the Iberian Peninsula. In the north of Europe these deadwood knees are relatively common, connecting the keel or keel planks to the sternposts. The Iberian stern knees, in Portuguese *corais da popa*, appear in the Corpo Santo (c. 1400), Aveiro A (c. 1475), possibly in the Studland Bay (c. 1525) and *San Esteban* (lost 1554), *San Juan* (lost 1565), as well as Esposende 1 and Angra D (c. 1600). In the Mediterranean similar timbers seem to be part of the stern arrangements of *Lomellina* (lost 1516) and Calvi 1 (c. 1575), although erosion of the upper portion of *Lomellina*'s overlaying timber does not allow a definitive statement.

6.8 Y-Timbers Tabbed to Deadwood

This feature is found in many European ships of this period and cannot be assigned only to the Iberian Peninsula building traditions of the early modern period.

6.9 Keelson Notched over Floors

This feature is also found in many European ships of this period and cannot be assigned only to the Iberian Peninsula building traditions of the early modern period.

6.10 Maststep Is Expanded Keelson

This type of maststep seems to be common practice in northern Europe and in the Iberian Peninsula, but not in the Mediterranean.

6.11 Buttresses and Stringers

This feature is also found in many European ships of this period and cannot be assigned only to the Iberian Peninsula building traditions of the early modern period. The Mediterranean vessels from Boccalama, a galley and a *rascona*, both have buttresses granting lateral support to the maststeps, and the same is true for the Contarina 1 vessel.

6.12 Ceiling/Filler Planks

These small planks covering the spaces between the frames were found on the Cavalaire-sur-Mer Basque shipwreck (c. 1475), and in the Highbourne Cay (c. 1525) shipwreck, as well as in the Basque ship *San Juan* (1565), the French-built vessel Arade 1 (c. 1580), and the Mediterranean vessel of Calvi 1 (c. 1580).

6.13 Rigging Chain Assemblies

This feature is also found in many European ships of this period and cannot be assigned only to the Iberian Peninsula building traditions of the early modern period. Iconography suggests that deadeyes were tear shaped in most European ships of the sixteenth century.

6.14 Flat Transom

This seems to be a feature common in the sixteenth century, and not exclusive to the Iberian Peninsula. Flat transoms are almost generalized after 1500, in Mediterranean, Iberian, and North European vessels.

6.15 Carved Garboard

This feature is also found in many European ships of this period and cannot be assigned only to the Iberian Peninsula building traditions of the early modern period.

Perhaps one of the most interesting elements of this study is the fact that during the fifteenth century most northern European maritime powers adopted the Mediterranean skeleton-based shipbuilding method, and the Mediterranean merchantman model, with three or four masts and well-integrated fore and stern castles,

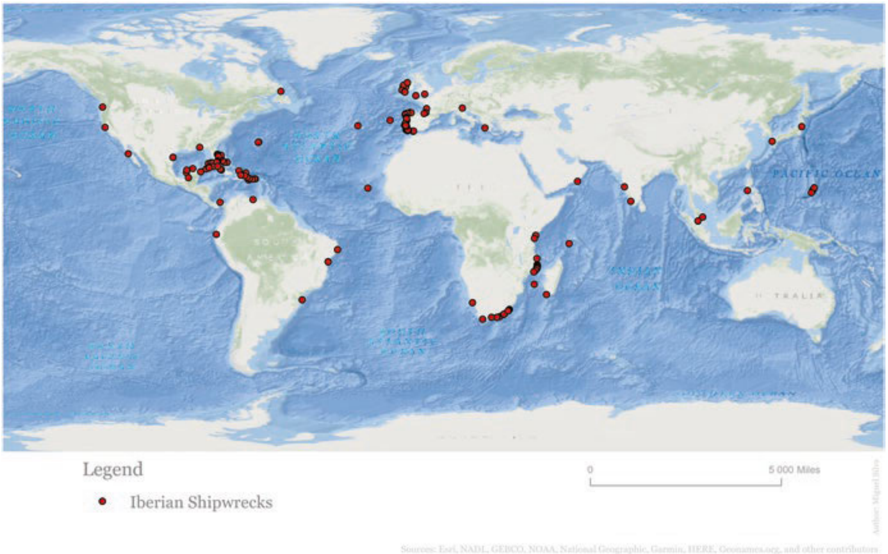

Fig. 4.1 World map with a distribution of possible Iberian shipwrecks (Miguel Silva)

making it even more difficult to pinpoint the Mediterranean (mostly Italian) shipbuilding *memes* adopted directly from Italy into Portuguese and Spanish shipbuilding methods, and those that arrived in the Iberian Peninsula via the north of Europe.

An important factor to compound at this point is the difficulty to identify the country of origin of a ship or boat. Ships were bought, seized, rented, and repaired, and without good dendrochronology data it is not possible to know for sure where a ship was built. Ships were sometimes also built with imported timber. It is, therefore, difficult to know for sure where some of the architectural signatures started or how they eventually spread into different cultural landscapes.

Nevertheless, the construction of history is an iterative process. Scholars propose narratives and test them against new or overlooked data. In Fig. 4.1 we present a map with the shipwrecks that we believe could have been built on the Atlantic coasts of Portugal or Spain. This is a tentative and provisory map and, as mentioned above, only dendrochronology studies will allow us a better understanding of these ship's technological roots.

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Chapter 5
Ship Types in Portugal and Spain

Filipe Castro and José Virgílio Pissarra

Abstract This chapter is a contribution to the present understanding of a certain number of ship names that appear in historical documents. The diversity of watercraft that populated each harbour in the Iberian Peninsula of the sixteenth century is impossible to reconstruct, but we have enough information from both archaeological sources and archival research to propose some definitions of types such as *naos* and *galeones*, *barcas,* and *caravelas* through time, and describe the variations recorded for each of these typologies.

1 Introduction

A look at any sixteenth century harbour view, from Lisbon to Madrid, Genova, or Venice, shows a diversity of watercraft. Ships and boats of all sizes are propelled by sails, or oars, or both, some large and decked, conceived for long voyages in the high seas, sometimes with large castles on the bow and stern, others smaller, with sometimes long and elegant hulls, sometimes beamy and capacious, depending on their function and the nature of the waters where they were supposed to operate. Riggings varied as well, from the simplest spritsails to the large and complex lateen sails of oceangoing galleys, which needed large crews to be safely operated.

The names of each of these types varied regionally and through time, and it is sometimes difficult to understand what a certain designation means. To complicate things further, Casado Soto reminds us that most documents mentioning boats and ships were written by bureaucrats that, at times, may not have been fully aware of the intricacies of ship naming. He cites a 1522 document from the Spanish *Archivo General de Indias* which mentions four *naos*, caulked (*calafetadizas*), all of oak wood (*de banço de robre*), with capacities from 50 to 90 *toneles*, five new *chalupas*, on the stocks, made of oak heartwood and lapstrake built (*de madera de robre e*

F. Castro (✉) · J. V. Pissarra
Universidade Nova de Lisboa (UNLA), Lisbon, Portugal
e-mail: fcastro@fcsh.unl.pt

A. Crespo Solana et al. (eds.), *Heritage and the Sea*,
https://doi.org/10.1007/978-3-030-86460-6_5

tingladas de borne), with capacities from 35 to 40 *toneles*, three *pinazas* of oak, caulked, with capacities up to 40 *toneles*, and another eight lapstrake built, with capacities from 35 to 40 *toneles* (Casado Soto 1998, p. 175). And the document concludes saying that all the *chalupas*, including *chalupas* and *pinazas* in this group, are built without castles (*son navíos razos*), built for fishing, for which they go to the kingdom of Ireland and Andalucia.

Half a century later, around 1580, the Portuguese priest Fernando Oliveira wrote in the introduction chapters of his treatise *Liuro da fabrica das naus* that the types, shapes, and names of ships and boats changed fast, following fashions and innovative trends that made it almost impossible to keep up. In his particular style, father Oliveira explains: The "names of types and forms of ships and boats of one kind or another are almost unfathomable; both because they are many, and because of the way they change from time to time, and from place to place. The same type of ship has one name in Spain, another in France, and another in Italy. In Spain they call *naos* to the ships called *carracas* in Italy and *urcas* (hulks) in Germany". And he continues: "In Portugal we call *barcas* to the boats that in Galicia are called *trincados* (in Spanish *tinglados*, or lapstrakes), without much noticeable difference in their appearances. And in what pertains to time, "less than 40 years ago nobody in this land (Portugal) knew the names *zabra*, nor *lancha*, and now they are common. And as some names came anew, others fall out of use and are forgotten and never used again. And of the present types, some lose their names, others change their shapes. The boats from Santarém now rise their heads, and *cervilhas* are now called *muletas*" (Oliveira 1995).

It is not easy to define a ship type in a world constantly changing, as shown for instance in the scholarly discussions about the definition of the cog (Maarleveld 1995; Crumlin-Pedersen 2000; Hoffmann 2001). Knowing that today it would also be difficult to provide an absolute definition of SUV or truck that exercise is nevertheless useful and necessary for a better comprehension of some aspects of the seafaring life and maritime landscapes throughout the Iberian Peninsula.

This chapter provides information on the definition of ship types that were common in Portugal and the Iberian Peninsula in the early modern period.

2 Barca

Barca is a vague designation of a range of small and medium sized ships. It is impossible to define this type, as the word's meaning varied through time and from port to port. The *barcas* mentioned by the Portuguese chroniclers of the Iberian Atlantic expansion were certainly not a single type, built for the exploration of the West African coast. The name appears in historical documents before the foundation of Portugal, and still designates a small vessel, generally undecked. In the nineteenth century this word designated a barkentine-rigged ship.

Casado Soto believes that the name refers to a northern type, arriving in Portugal from Atlantic France, Brittany, Flanders, or England, and mentioned in Spain along the same lines, there with capacities of 60 *toneles* (Casado Soto 2012, p. 204). He makes a distinction in gender, suggesting that when the name is referred as masculine, *barco*, it refers to a small, rowed boat, a designation that seems plausible also in Portugal (Casado Soto 2012, p. 209). This assumption is reinforced by Fernando Oliveira, already mentioned above, who describes the Portuguese *barcas* as similar to the Galician ones, which were lapstrakes in the Baltic and north Atlantic manner.

The type appears in Portuguese and Spanish documents from the twelfth century onwards, sometimes in the form of *barchas* or *barquas*, similar to the *barche* or *bargue*, of northern France dialects (Pico 1963, p. 51), *barge* or *bark* in England (Friel 1995, p. 147), or *barca* and *barxa* in Spain (Vela i Aulesa 2000, p. 634).

In the 1255 chart of the village of Vila Nova de Gaia, in the north of Portugal, *barcas* are referred together with *naves* and *navigia*, as being larger than pinazas: "*naues et barce et nauigia que fuerit maiora quam pinatia*" (Fonseca 1930a, p. 355). Carbonel Pico refers a 1297 document that seems to suggest that the designation *barcas* applied to *naves*, *baixéis*, *aloques* (hulks), and *cocas* (cogs)—"das ditas Barcas (sc. naves, baixéis, aloques e cocas)"—suggesting that these types could all be designated as *barcas*. She also mentions the existence of *barcos* with capacities above 100 tons engaged in the north European commerce in 1293, and a light *barca* with a gun, powder, and crossbows – "*uma barca ligeira com um* '*troom que tirava muito, e pollvora, e beestas'* referred in a fifteenth century document (Pico 1963, p. 34 and 38).

In Spain, towards the end of the sixteenth century, Diego Garcio de Palacio uses the expression "*barca do trato"* to describe a specific type: "*Los navíos que usan la costa de la Nueva España desde Cozumel hasta Panico (…) casi generalmente las hacen, el plan cuanto es mitad de la boca, y el puntal de dos tercios, (…) son de porte de 50 toneladas y llámanlas Barcas del trato: el arboladura es como las de las fragatas ya dichas*".

In his 1672 list of the types of Spanish watercraft, José Veitia Linage mentions *barcos*: "*Barcos ay de diferentes maneras, vnos masteleros de velas de gavia, y destos se llaman los mayores Gavarras, q las suele aver de 150. pipas, y los menores, Barcos otorgados, que son vn medio entre las Gavarras, y los Barcos luengos, y estos vltimos son el mas ligero genero de embarcacion q se ha inventado*" (Veitia Linage 1672, p. 169).

3 Caravelas

Caravels are among the least understood of all historical vessels. Mentioned in hundreds, perhaps thousands of books, these ships are associated with the Iberian exploration of the Atlantic in the fifteenth century, and are considered the *space shuttles* of their time, allowing the Portuguese and Spanish explorers to sail down the African coast, and thus open the maritime routes to the Caribbean region, the west coast of Africa, and the Indian and Pacific Oceans. A few authors have dedicated more or less lengthy works to this ship type, such as Quirino da Fonseca

(1930b, 1934), Pimentel Barata (1989), Tengarrinha Pires (1980, 1985, 1986, 1988, 1990), Malcolm Elbl (1985), Francisco Contente Domingues (2004), or George Schwarz (2008).

Their agility is legendary, and more than 150 years after the first mid-fifteenth century references to the new exploration caravels, they are still mentioned, in an account of a 1597 expedition to the Azores under the Earl of Essex, as fast and highly manoeuvrable: *Whilest we thus stayed about the Rocke, ye carvalls of Lyshbourne and of the parts thereabouts would daylie come swarminge about us like butterflies soe neare us as that we might cast a stone into some of them, and yet could we never catch any one of them, soe warie and nimble they are.*[1]

The ships developed in the early modern period allowed the exploration of the planet. After a long process of perhaps 200,000 years of migration, isolation, and differentiation, in the fifteenth and sixteenth centuries, humans sailed, mapped, and explored the globe. Cultural and economic changes brought about by the exploration of the planet are complex and intertwined, but the development of large ocean-going ships, capable of sailing over six months without touching land, is one of the most important technological developments of this period. Many historians believe that the European maritime expansion started with the development of fast and agile caravels, capable of reaching at angles to the wind that made it easy to explore, fish, hunt, and trade along the West African coast, and sail back to Europe against the prevailing winds and currents.

There is no question that these vessels originated in the Mediterranean, and there is no question that they represented some technological improvement in northern Europe. The Portuguese and the Spanish probably changed and adapted this type of vessels to the navigation along the coast of Africa. Venetian merchant and chronicler Alvise da Ca′ da Mosto wrote in the late fifteenth century: "…*essendo le caravelle di Portogallo i migliori navilii che vadino sopra il mare di vele, ed essendo quelli bene in punto d'ogni cosa che gli fa di bisogno*…" (Ramusio 1606, vol. I p.105). Ca′ da Mosto mentions eyes painted on the bow of these caravels, something characteristic in the Mediterranean since long. He says, about the inhabitants of the African coast: "…*e pensavano che gli occhi che si fanno a prova alli navilii fussero veramente occhi, che 'l navilio per quelli vedesse dove gli andava per mare*" (Ramusio 1606, vol. I p.114).

To this day the expression "carvel-built" refers to watercraft built with flush-laid planks, nailed to pre-erected frames, a structural improvement that originated in the Mediterranean and spread along the Atlantic coast of Europe, into the north and the Baltic, during the late fifteenth and early sixteenth centuries.

Much has been said and written about caravels, but these vessels have never been thoroughly described in historical sources, their representations are few and impressionistic, and no ship identified as a caravel has been archaeologically

[1] Richard Barker kindly shared this reference with me, taken from an account, probably by Sir Arthur Gorges (1569–1625), of the 1597 expedition against Spain. CSP DOM Conway Papers 1604, xxxvi No 94. Addendum 1580–1625. *An account of an expedition under the Earl of Essex against the Western Islands*.

excavated to this day. Replicas have been built with mixed results, never based on solid supporting information. This section is a tentative summary of what is known about these ships, both from documental sources, written and iconographic, and from the archaeological record.

Pictures of caravels labelled as such are rare but clear enough to allow historians, already in the nineteenth century, to have a fair picture of what they may have looked like. Portuguese historians Quirino da Fonseca (1934) and Tengarrinha Pires (Pires 1980) inventoried the most important representations of caravels in existence. Pimentel Barata (1989) published an interesting drawing of a caravel, depicted as the signature of a caravel master from the fifteenth century named João de Lião, dated to 1488 according to the author. This drawing was first published by Avelino Teixeira da Mota (1971, Fig. 4) who noticed that this is the earliest drawing of a caravel, designated as such, and one of the earliest dated representations of a stern panel, which is clearly defined.

There are more illustrations of caravels than those indicated by the authors above mentioned, of which perhaps the most interesting come from the Mediterranean, but the access to images is too difficult and expensive to allow a comprehensive edition of this iconography.

3.1 Documental Evidence

Before 1500 we can only guess what the word "caravel" means. All we have to work with are a few textual references: medieval boats named *carávos*, two twelfth century Italian references to a type of boat called *Caravellum*, one thirteenth century reference to *caravelas* in the chart of the Portuguese village of Gaia, one fourteenth century reference in Spain, and the fifteenth century caravels of the Discoveries.

Auguste Jal and Corominas explored the origins of the words *cáravo* and *qârib*, both referring to small boats, sometimes coracles. As to the word *caravellum*, there is no way to tell what kind of boat the 1159 Genoese *caravellum coopertum* was. These boat types appear in two Genoese twelfth century documents, the first mentioned is decked (*coopertum*) serving a *navis* (1159) and the second (1190) is small, belonging to a *caravelator*, presumably working as a harbour tender (Ciciliot 2005). Furio Ciciliot points out the fact that in the twelfth century the word *caravelum*, referring to a small boat, is masculine, and does not become feminine until it is assimilated to a larger vessel: *navis sive caravellae* (Ciciliot 2005).

Historian Malcolm Elbl mentions a 1226 reference to a Portuguese caravel taken by English ships on a return trip from Gascogne (Elbl 1985, p. 546). He cites the French translation Francisque Michel's *Histoire du commerce et de la navigacion à de Bordeaux* (Michel 1867, p. 153). Michel mentions only "*un navire portugais, appelé le Cardinal*" and indicates the *Rotuli Litterarum Patentium*[2] and the *Rotuli*

[2] Rot. Litt. Pat., 10 Hen. III, m. 5

Litterarum Clausarum[3] as her sources. The *Rot. Litt. Pat*., mention a "*navem que vocatur la cardinale*" (1971, p. 36), and the *Rot. Litt. Claus*., *Membrane 14*, mentions an unrelated incident pertaining to wine trade with Bayonne (1916, p. 5). I could not access *Membrane 27* of Henry's tenth year, and I am not sure that all of Henry's rolls are published.

The caravels referred to in the Chart of Gaia (1255) seem to be fishing vessels, of which we know nothing. In Portugal caravels are feminine, even though they appear compared to *navios*, which are masculine (*caravela sive navigio*). But in Portugal the gender of the boats or ships does not seem to be associated with their size. It is likely that all these caravels were lateen rigged from the beginning. Square-rigged vessels were rare in the Mediterranean between the early sixth century and the mid-thirteenth century, and most references to caravels mention lateen sails (Bellabarba 1999).

Some authors have proposed that caravels were mentioned in Alfonso X's *Libro de las Leyes* or *Siete Partidas*, as it is better known, written between 1254 and 1265. Most authors, however, agree that the passage in question – Partida Segunda, Titulo XXIV, Ley VII – mentions *haloques*, and not *caravelas*.

It seems that caravels are not mentioned in Portuguese documents during the fourteenth century. There is a reference to caravels in 1307. Malcom Elbl (1985)) places it in Biscay, Spain, and cites Quirino da Fonseca. Quirino cites Auguste Jal, and places the caravels in northern Europe (1934, vol. 1 p.21), and Jal (1848) is silent about the place and cites Pierre Carpentier (1766), who does not place these caravels anywhere, and gives a source for it I could not find: *Charta an. circ. 1307*.

From the mid-fifteenth century onwards, chroniclers mention caravels engaged in the exploration of the Atlantic, and later carrying Columbus into the New World. There are some documents describing caravels, the best-known pertaining to the caravels *Niña* and *India*, used by Columbus in his fourth trip (Smith 1993, pp. 239–256), or the *caravelões* de Arguim published by Alexandre Monteiro (Monteiro et al. 2011). Carlos Etayo transcribed a 1450 contract for the construction of a caravel for a Catalonian *mariner* named Gracia Amat with one central and two side rudders, and a length to beam ratio around 4/1 (Etayo 1971, p. 125). Jacques Paviot and Erich Rieth published a paper relating the construction by Portuguese shipwrights of two caravels in Brussels, in 1438 and 1439, for the Duke of Burgundy, Philippe *le Bon* (Paviot and Rieth 1988).

An extensive bibliographic research has not been done in Italy, where caravels probably originated. Lucien Bash refers to 24 caravels sent by the Republic of Venice in 1490, with 24 men each, and 30 caravels in 1499 with capacities between 100 and 400 *botte* (Basch 2000). A *botta* was close to half a Portuguese *tonel*, if we are to trust a 1519 document mentioned by Lane (1964): "*Per lettere di Sibilia delli 9 ditto erano avvisi, come a di 6 era venuta una caravella di portata de 60 tonelle,* videlicet *120 botte, a qual era stata a discoprire le Indie (Mexico) …*" (Fulin 1881, p. viii, note 2).

[3] Rot. Litt. Claus., 10 Hen. III, m. 27 et 14; t. II p. 89, col. 2; et p. 119, col. 1

Although Portuguese and Spanish historians combed the most important European archives more than one century ago (Domingues 2004), almost nothing is known about caravels during the sixteenth century. Around 1600 we have the first lists of timbers for the construction of a caravel in the Lisbon National Library manuscript known as *Livro náutico,*[4] dated to the 1590s, and two cryptic *regimentos* by Manoel Fernandez, dated to 1616 and illustrated, but difficult to understand (Fernandes 1989). A computer model developed by Dr. Nuno Fonseca's team at Lisbon's Instituto Superior Técnico, based on Fernandes' drawings, showed to be implausibly unstable, and suggested that the vertical and horizontal scales we different in the original drawing.

Iconography is scarce and does not shed light on the most important questions. For instance, they do not tell us whether the early Portuguese fifteenth century caravels had a stern panel and a central rudder. Around 1500, when we have the first images and descriptions, caravels seem to be small ships of 15 to 50 tons, built with flush-laid planking, rigged with one, two, or three masts, all mounting lateen sails. Sometimes they appear with a foremast rigged with a square sail. Generally, the mainmast is placed on the centre of the keel, and the second and third masts are stepped abaft it, with a small stern castle and no forecastle, a stern panel and a central rudder.

Central rudders first appear in Denmark, in the twelfth century (Hocker and Dokkedal 2001). The earliest explicit reference to a central rudder is probably Gracia Amat's contract, in the middle of the fifteenth century. Stern panels appear in the iconographical record after 1475, and at least in the fifteenth century iconographical record, central rudders seem to be characteristic of square-rigged ships.

As it often happens, the word caravel designated a wide range of watercraft, even in the sixteenth century: c*aravelas latinas*, *caravelas de Alfama*, *caravelas redondas*, *caravelas de armada*, and *caravelões*. In some cases, we have a fair idea about the main differences between them, and in other cases circumstantial evidence allows some provisory hypothesis. The following are the presented short descriptions of what each type may have looked like.

3.2 Caravelas Latinas

As already mentioned, during the fourteenth century they are not mentioned in Portuguese documents. In the mid-fifteenth century caravels appear as *lateeners* with a capacity around 50 *tonéis* and crews between 20 and 25 men. It looks like small caravels with 2 or 3 masts with lateen sails endured for over one century without much change. But we do not know what characteristics defined a caravel or what separated a caravel from the other lateeners of their time.

[4] *Livro Náutico, ou Meio Práctico de Construção de Navios e Galés Antigas. Biblioteca Nacional de Portugal. Codex 2257*

Quirino da Fonseca mentions Braancamp Freire describing 54 *caravelas* leaving Lisbon in 1488 and 1489, with capacities varying between 15 and 50 *tonéis* (da Fonseca 1935, p. 177).

This range of capacities is compatible with other accounts, some written much later. In 1571, in *A vida e feitos de el-rei D. Manuel*, D. Jerónimo Osório, describes caravels as rather small vessels. These caravels do not have tops (*cestos de gávea), nor their yards make right angles with their masts, but hang, inclined, secured under the masthead, and the base of the sail is triangular and almost touches the bulwarks. The yards, which are fastened to the ship's bulwarks, are as thick as top-masts in their lower part and have smaller sections upwards* (da Fonseca 1935, p. 216).

Sometimes these small two- and three-masted lateeners are referred as typically Portuguese, but José Luis Casado Soto found references to 125 caravels in the *Registro General del Sello* in the *Archivo General de Simancas* between 1476 and 1496, and they seem to come from all over the Iberian Peninsula. His figures show that 45% of the caravels registered were from Andalusia, 21% from the Cantabric region; 19% from Portugal, 12% from the Mediterranean, and 3% from France, England, and the North Sea (Casado Soto 1989).

There is no mention of any possible difference between them. Were Cantabrian and Andalusian caravels much different from each other? How different were they from the Portuguese ones? Or how did the Portuguese ones differ from each other?

We have a long way to go before we can say that we understand this ship type. Iconography can provide some clues if we are to trust the illustrations in the Atlas of Georg Braun (1541–1622), published between 1572 and 1617. The quality of the illustrations in Braun's Atlas is known, including the figures in local dresses. It was not uncommon for painters and illustrators to register in the mapmaker's guilds and work on map illustrations when they had an opportunity (Binding 2003, pp. 39–43; Unger 2010, p. 2). The ship illustrations in Braun's Atlas seem to be reliable as well and vary from city to city. Although no systematic study of the Atlas' ships has been done yet, the caravels represented in several Portuguese and Spanish cities, in Iberia or around the world, seem plausible and accurate, and consistent with the following descriptions.

3.3 Caravelas de Alfama

Paulo Monteiro found this reference in a Spanish late sixteenth century document: "(…) *Tambien se quedan despalmando dos caravelas pequenas destas que aqui llaman de Alfama que las pide el Almirante para llevar consigo…*" (Monteiro pers. comm. 2009).

Were at least some of the Spanish caravels larger than the Portuguese ones? José Luis Casado Soto mentions a witness account of Columbus' second voyage, in which Pedro Mártir de Anglería claims that Columbus took 17 vessels: three large cargo ships with tops, 12 caravels, and two large caravels, *with masts large enough* *to support tops*. Nothing is said about their rigging arrangements. Were these typically different from those of the Portuguese caravels?

3.4 Caravelas Redondas

Navarrete calls *caravelas redondas* "*castellanas*". They have three masts, the foremast mounting a square sail and the main and mizzen masts mounting lateen sails. Quirino da Fonseca cites him: "*caravels were divided into Portuguese and Castilian, the first exclusively lateen-rigged, could sail* cinco ou seis quartas (56° to 67°) *into the wind, facilitating the Portuguese routes to the African gold mines. Castilian caravels used in their seas with square sails, or better, with a square sail on the foremast*". Quirino also refers to a 1512 letter from D. Fernando to Pedrarias Davilla in Panama: "*Yo vos mando que … se hagan luego tres o cuatro carabelas, al modo de Andalucía, las dos, e las otras dos, pequeñas, latinas, como las de Portugal …*" (da Fonseca 1935, pp. 220–221).

In Columbus' *Diario de a bordo*, transcribed by friar Bartolomé de las Casas, the entry for August 9, 1492, famously mentions the explorer's decision to change the rigging of his caravel *Pinta*: "*y adobaran muy bien la Pinta con mucho trabajo e diligencias del Almirante, de Martin Alonso y de los demás; (…) Hicieran la Pinta redonda, porque era latina"* (Colón 1991).

In the fourteenth century Mediterranean it was common to rig two-masted cargo vessels with a square sail on the foremast and a lateen sail on the mizzen. Sergio Bellabarba called this rigging arrangement *quadra-latina* and proposed two possible roots for the development of three-masted, ship-rigged vessels, one from the two-masted lateeners and one from the one-masted square-rigged cogs, both common merchant ships in the mid-fourteenth century Mediterranean (Bellabarba 1999). According to Bellabarba's plausible theory, both ship types at some point may have adopted a *quadra-latina* rigging arrangement, the two-masted lateeners by changing to a square mainsail, the cogs by adding a lateen-rigged mizzen mast. The earliest representation of a ship-rigged three-masted vessel dates to 1409 and appears in a Catalonian document. It shows a *cocca* with a *quadra-latina* rigging arrangement to which a foremast was added, mounting a square sail (Mott 1997). *Caravelas redondas* seem to have evolved in a similar way. It looks like they were two-masted lateeners – which show the mainmast always stepped on the middle of the keel – with a third mast, a foremast stepped far forward. This type of vessel is represented in Braun and Hogenberg's *Civitates orbis terrarium*, especially in Spanish harbours.

Two documents dated to 1498 (before Columbus' fourth voyage) contain the inventories of the rigging of two caravels, *Santa Clara*, or *Niña* (60 *toneles* – probably not the *Niña* of the first voyage – and *Santa Cruz*, or *India*, built in Hispaniola during the second voyage with the remains of the ships lost in the hurricane that swept La Isabela in 1495.

Both these caravels had four masts, and both had square sails on the fore and main masts, and lateen sails on the mizzen and Bonaventure. Additionally, *Santa Cruz* had a bowsprit and a spritsail; and *Santa Clara* has "*dos botalos vno del trinquete y otro de la cont[ra]*" (Smith 1993).

Gaspar Correia states that Vasco da Gama sailed to India in 1502 with "*cinco caravelas latinas, que mandou muito bem concertar*" and "*iam com velas redondas armadas, para com elas navegarem quando cumprisse*". He does not mention how many masts these ships had, and the representations we have date to around 1565, more than half a century later.

Large cargo ships – *naus or naos*, *caracche*, or *hulks*, as they were known in the Atlantic, Mediterranean, and Baltic – tend to have three masts and square sails on the bowsprit, fore, and main masts, and a lateen sail on the mizzen mast.

When a fourth mast appears, in the late fifteenth century, square sails are always present, either on the fore and main masts or only on the foremast. The first type of rigging is common on larger vessels, such as galleons, developed around 1500 or on the Spanish *caravelas redondas*, such as the *Santa Clara* and the *Santa Cruz*. The second type, with square sails only on the foremast, is typical of the Portuguese *caravelas de armada*.

3.5 Caravelas de Armada

It is curious to notice that in the 1550s Fernando Oliveira is skeptical about the qualities of the *caravelas de armada*. In his *Arte da guerra no mar* he states: "*A mim me pareceu sempre, que caravelas de armada, não eram tão boas como são gabadas, por serem um género de navios misturado e neutro, e as partes que tomam de cada um dos outros géneros serem as piores*" (de Oliveira 1969).

In the middle of the sixteenth century, these caravels were purposely built with a forecastle and four masts, rigged with square sails on the foremast and lateen on the remaining three, and later would be as large as 180 *tonéis*. As mentioned above, there are two *regimentos* for the construction of these caravels in Manoel Fernandes' treatise (1989), and they both have two decks. We have their main dimensions:

- *Folios 16 and 107*: The caravel with 11 *rumos* (17 m) of keel has 23.2 m of length overall, a max beam of 6.42 m, a depth of hold of 4.1 m, and a flat amidships of 2.05 m.
- *Folio 24 (and 108?)*: The caravel with 12 *rumos* (18.5 m) of keel, has 25.5 m of length overall, a max beam of 7.19 m, a depth oh hold 4.40 m, and a flat amidships of 2.31 m.

These *caravelas de armada* have length to beam ratios of 3.61 and 3.55, respectively, values that are compatible with the extensive iconography, often with reliable, albeit impressionistic, characteristics.

3.6 *Caravelões*

It seems that the smaller caravels were sometimes referred to as *caravelões* (Pico 1963, p. 51). Alexandre Monteiro transcribed two early sixteenth century documents relating to *caravelões de Arguim* that describe 3-masted vessels with bowsprits, square sails on the fore and main masts, and a lateen sail on the mizzen (Monteiro et al. 2011). Both *caravelões* have hatch covers, so there is no doubt about the fact that they were decked, as it should be expected in ships that are engaged in oceanic trips. One of these *caravelões* had a crew (*companha*) of nine: pilot, six sailors, and two apprentices. This information gives us a hint of the ship's dimension, if we are to believe Fernando Oliveira, who one generation later, in the mid-sixteenth century, states that crews should be calculated as follows:

- Up to 10 *tonéis*: 2 sailors, 1 apprentice.
- 10 to 20 *tonéis*: 3 sailors, 1 apprentice.
- 20 to 30 *tonéis*: 4 sailors, 2 apprentices.
- Above 30 *tonéis*: add 1 sailor/4 *tonéis* and 1 apprentice/3 sailors.

According to Oliveira, both the master and the pilot must be counted as sailors, thus suggesting a ship with a capacity around 42 *tonéis* (de Oliveira 1969).

One of these documents (1508) is particularly interesting because it refers to a bowsprit, fore, and mainmasts, and a Bonaventure mast with its yard. Although there is no mention of a mizzen mast and yard, there is one mizzen sail and one mizzen halyard (*ostaga*). It is not clear whether this is a mistake or if there were *caravelões* with 4 masts.

The characteristics of these ships are indeed elusive. The established definition points to a smaller subtype of the *caravela latina*, a very small ship by itself, with the suffix "ão", usually an augmentative, having a diminutive meaning (see also Galleon in its primitive form), but this needs clarification. Truly, some examples were not only small, like the Drago attached to the Malacca squadron in 1524, but crude, like the one built from the wreck of the ship of Lopo Sanches, deliberately run aground on its outward voyage to India in 1505. However, the *caravelões* of the Portuguese Indian Fleet which, from 1517, were entrusted with special dispatches to Portugal, could not be of such modest dimensions, as a consequence of the scarcity of calls along the route and the slow pace of a small ship struggling against heavy seas, foiling the whole intent of the fastest communications possible. Nor were the ships of Arguim, studied by Monteiro et al. (2011), smaller than a *caravela latina*, whose tonnage all-out limit is known to have been 50 *tonéis*. One important detail is their square rigging, more so regarding ships involved in a route widely accepted to be adverse for non-lateen ships. This evidence, correlated with the fact that the *caravelão* sent home from India in 1517 needed the adjective "latino" added to *caravelão*, suggests that the ships were typically square-rigged, in other words a sort of square-rigged caravels. Towards the middle of the century, the Portuguese Crown started to build *caravelões* for its Atlantic Fleet. In October 1541 there were five, and two more were added to the fleet in January 1542. Four of the five vessels were significantly named after nimble birds of prey: Sacre (Saker falcon), Nebri (Peregrine falcon, ssp. *calidus*), Tagarote (Peregrine falcon, ssp. *pergrinoides*), and Gerifalte (Gyrfalcon), asserting their military nature. They were used operationally as dispatch, scouting and close escort vessels, giving the Navy its own resources to alleviate the dependency on the fishing caravels (*caravelas pescarezas* or from Alfama), usually employed in these very demanding tasks and generally considered less than adequate due to their makeshift nature and civilian crews.

4 Naus

Direct descendants of Mediterranean *cocche*, Portuguese and Spanish cargo ships are relatively well documented, although there are no technical documents that allow us to define the shape of the hulls during most of the two centuries to which this study refers, nor the apparatus or the dimensions of its structural components. On the one hand, the literature suggests the existence of a great diversity of constructive and structural solutions, and a great freedom of shipbuilders to adapt the ships to the demands of the moment. Citing Gaspar Correia, Quirino da Fonseca describes a past episode in India where Vasco da Gama, faced with a lack of barrels, had tanks built for water in the holds, using the technology available in the Indian Ocean: with sewn boards.

Technical texts on shipbuilding are concentrated in a relatively short period, around the last quarter of the sixteenth century and beginning of the seventeenth century and are well studied. During the first half of the seventeenth century the lines of the warships and trade ships converged—blurring the differences between ships and galleons—and the Spanish crown elaborated and published a number of important norms in an attempt to regulate shipbuilding and create typologies and classes defined by law. This effort is less visible in Portugal, which in the seventeenth century watched helplessly the decline of its commercial empire. From the third quarter of this century England and the Netherlands progressively took the lead in researching and developing new types of ships, which from this point onwards have specialized routes for war and commerce, first in England during the Cromwellian Republic (1649–1660), followed closely by Holland whose economic interests made three naval conflicts inevitable with England, which drastically changed Dutch shipbuilding. The first Anglo-Dutch war took place during the Cromwellian Republic (1652–1654), and the second and third occurred during the period of the Restoration (1665–1667 and 1672–1674).

In the second half of the seventeenth century, Portuguese and Spanish ships began to be built following the methods and principles developed in Holland and England. Basque naval builders, who had spent a period of crisis in the late sixteenth and first half of the seventeenth century, regained the tradition of excellence that existed in the Middle Ages and the Cantabrian region revived a period of renewal in shipbuilding during the second half of the seventeenth century. A good example of this renewal is the manuscript of José Antonio de Gaztañeta, *Arte de* *fabricar reales*, dated 1688, which follows the general forms of the ships of northern Europe, while maintaining the Mediterranean rules of the fifteenth and sixteenth centuries for the layout of the rising and narrowing of the ships' bottom.

It is not easy to describe in detail the evolution of ships' shapes during the 1500–1700 period. Although there are some contracts and documentation of ship sizes of various types in the second half of the seventeenth century, the history of Portuguese shipbuilding in the seventeenth century has yet to be done. A small number of archaeological findings, generally poorly studied and poorly published, allow us to establish some general lines of continuity in the design and construction of oceanic ships in the sixteenth and seventeenth centuries, especially when analysed in the light of the most reliable iconographic data to trace evolution of the shapes and rigging arrangements of Portuguese commercial ships.

Around 1500, these ships appear represented with very high and aft-tilted bow castles, much higher than the stern castles, as can be seen in the painting of S. João in Patmos, in Lourinhã City Hall (ca. 1475). Another feature of the late fifteenth and early sixteenth century ships is the pronounced curvature of the bow wales, which require the construction of a transitional surface between the hull and the wedge-shaped bow castle, reminiscent of the previous period when the castles were not integrated in the hull. This wedge-shaped surface can still be seen in the *Livro Carmesim* ship (1502) but is less evident in the Atlas Miller ship (1502) or in the Duarte of Armas *Livro das Fortalezas*' ships (ca. 1509).

By 1510, this surface is still represented in the Atlas of Jorge Reinel, but by 1517 the bow castles of the ships of the Santa Auta Altarpiece are almost perfectly integrated into the ship's hulls and the stern castles in some cases grow considerably. Around this date stern panels appear in Portuguese iconography. For example, one of the illuminations of D. Manuel's Book of Hours—circa 1517—shows eight ships under construction on the Lisbon river, of which five have the sterns facing the river, in the Portuguese way, and all have stern panels.

From the 1510s onwards the bow castles began to lower and there was a tendency to represent them at about the same height as the stern castle. This is what you see around 1530, in the ships of the painting attributed to Patinier, *Carracks on a Rocky Coast*, in the ships of view of Lisbon from the University Library of Leiden, dated from 1530 to 1550, or in the Breviary of the Countess of Bertiandos (c. 1535). Not all ships are built with panel sterns. Leiden's view appears to contain a ship, though depicted in profile, with a round stern—at least judging by the runs of the stern planks. The ship of the Countess of Bertiandos' Breviary has a round stern.

Around 1540, the representations of D. João de Castro's writings show the castles still at about the same height, but both much lower than those of previous decades. The differences between *naus* and galleons are evident in these excellent-quality drawings, and on the "Tábua das Portas do Estreito" appears a naval caravel without a bow castle. The sterns appear to be square – with a stern panel or square tuck – in the "Roteiro de D. João de Castro" and round in the "Roteiro do Mar Roxo".

Unfortunately, we do not have high quality iconography for the decades following D. João de Castro's illustrated manuscripts, except for Gaspar Correia's drawings, which are impressionist but excellent. The depictions of naval ships and caravels in the *Livro de Lisuarte de Abreu* (c. 1565) and the *Memória das Armadas* (ca. 1566) are quite stylized, although all the sterns represented appear to be of panel and in some cases the forecastle is lower than the stern one.

Images of Portuguese ships do not abound in the Philippine period (1580–1640). Like Lepanto's iconography, the frescoes of the Escorial and Viso del Marquez are quite stylized, and the best representations were probably derived from Pieter Breugel's (1525–1569) images, which are excellent and still quite current around 1580. At least from the mid-sixteenth century, iconography suggests that the forecastles of Spanish and Portuguese ships were different, the former built aft of the stem with a trapezoidal plan, leaving a small triangular area free ahead, and the second maintaining the typical triangular shape of Mediterranean ships, in Portugal with two floors and ending with a pronounced vertex in front of the stem.

The iconography of the 1588 navy shows narrower stern castles than in the previous centuries and looking more forward-leaning.

Hendrick Cornelisz Vroom's paintings, dating from the turn of the century, illustrate the gradual process that led ships from the mid-second quarter of the seventeenth century onwards to change their profile, lowering the stern castles and increasing their trim forward, and lowering the forecastles completely. Forecastles almost completely disappeared in the mid-seventeenth century.

The ships designed by Manuel Fernandes in 1616, in Portugal, announce this evolution, showing lowered bow and stern castles. The depictions of the first half of the seventeenth century show a slow evolution, as for example in the well-known Igreja dos Francesinhos, in Lisbon, where ships with low forecastles and narrow forward slopes are represented alongside the traditional late sixteenth century *naus*.

Ships from the 1620–1650 period are poorly documented in Portugal. The views of Lisbon from the City Museum in Lisbon show us an evolution of the profile of the upper works and the rigging that closely follows the evolution of the English and Dutch ships, well documented in this period. In the early seventeenth century, northern Europe saw a new type of painting appear in which ships were no longer part of the landscape but became the main motif of the artworks.

Although it is easy to observe a gradual evolution of the shape of the hulls and rigging - and from the middle of the century, also the batteries - regional differences in the arrangement of interior spaces, and in the shape and decoration of the upper works, allow us to identify styles and trends from the different European regional baroque tastes. Passionate about ships, Willem van de Velde (1611–1693) documented the evolution of Dutch and English shipbuilding during the seventeenth century through thousands of sketches, drawings, and paintings, of great aesthetic and formal quality.

5 Navios

The term navio seems to apply consistently to a small type of three-masted vessel, arming the same rigging arrangement as the larger *naus* or *naos*, but with rather small tonnage.

6 Navetas

Navetas were ocean-shaped ships, but smaller in size, probably without battery, carrying some artillery pieces like the ships, but built for trade. According to Leitão and Lopes, in the mid-seventeenth century, navetas appear to have been the three deck ships, so designed to differentiate themselves from the four deck ships.

7 Galleons

No other Portuguese ship type was the subject of greater controversy, regarding its origin, nature, and purpose, even though that can be mostly related to historiographic misunderstandings and less to any particular intricacy or documental obscurity more than what involves any ancient ship type. In fact, the Portuguese galleon, as the foremost Portuguese warship of the sixteenth and seventeenth centuries, is reasonably well represented in the primary sources, and more coherently than its relative, the war caravel (q.v.), which was never the subject of a similar debate, notwithstanding its origins being unknown.

Based on the Mediterranean sailing galleon, the Portuguese galleon was purposely designed for naval warfare by the Portuguese State, starting from 1518, considering the vast extent of its seaborne network and the characteristics of the naval opposition within. These requirements resulted in a type with a much larger medium tonnage, greatly improved heavy seas capability, range, robustness, and firepower; a set of characteristics already patent in the earliest units, signalling, from the beginning, a marked difference between the Portuguese type and its original reference. As far as the evolution of the warship is concerned, the Portuguese galleon is the most significant and influential of the ship types deliberately planned and introduced by the Portuguese State in the sixteenth century; other notorious example being the war caravel, the galleon's lighter counterpart. However, while the details of the introduction of the latter type are scarce or non-existent, there is satisfactory evidence of the shipbuilding programme that led to the inception of the Portuguese galleon, which took place simultaneously in Belém, in the outskirts of Lisbon, and in the Portuguese shipyards of Cochin (Kochi/ Cochim) and Calicut (Kozhikode/Calicut), in Kerala, SE India, between 1518 and 1520.

The first piece of evidence to be considered is the acquittance of a certain Simão Dias, knight of the Royal Household, following the end of his term of office as overseer of the "galleys and galleons that were made in Belém during the years of 1518, 1519 and 1520".[5] One should note, however, that Dias was the second overseer to take charge of these works, being preceded by a Diogo Chainho, of whose term of office he had been the clerk and from whom he took over the office in 1518. Probably late in the year, since Chainho was still in charge in the tenth of July, when

[5] - ANTT, *Chancelaria de D. João III*, *Doações*, 22, fl.79; partially publ. in FREIRE, CQ757.

he received 500 *cruzados* for the "works of the galleys" and "galeos".[6] This wording is explained by the fact that under the programme, besides five galleons, were also built in Belém two galleys, two galiots, one *fusta*, one *bergantine*, eight *batéis*, one *nau,* and one *taforeia*. All for the cost of 7,188,606 reais, a very modest sum, even more so when we consider that part of the fitting out was accounted for, albeit not the very expensive artillery. At the same time and under the same shipbuilding programme, two galleys were built upriver in the Tagus and five more ships, in an uncertain yard, but probably in the Atlantic port of Pederneira (Nazaré). The oared ships were intended to bolster the Portuguese naval presence in the Strait of Gibraltar and surrounding waters and were based in Algarve in 1520. The galleons, however, were dispatched to India as soon as they were completed: three in 1519 and the remaining pair in 1520. A Castilian spy spotted the 1519 trio and took note of their burthen in *toneles* (see Table 5.1). He also made some interesting remarks, noticing that the ships were intended for fleet work and that fact was among the reasons why they carried no cargo, just artillery and supplies; moreover, explaining why besides cargo, the ships were not entrusted with money chests, there were safety concerns due to their extreme reluctance to steer properly, as a result from design or building errors, made by what is suggested to had been a single shipwright.[7] While this can attributed to strangeness in the face of novelty, the 1519 positioning voyage of these ships to India, which was to be the inaugural voyage of the new type, seemed to vindicate all that criticism. The fleet, totalling 14 big ships, left Lisbon too late and as a result only four vessels were able to reach India that year. For the galleons, it was a disaster. The yet unidentified galleon commanded by Diogo de Noronha (or Diogo de Lima) aborted and returned to Lisbon. The *Santo António*, the smaller of the three, was the only one to round the cape of Good Hope, but after a tragic odyssey along the East Coast of Africa and the demise of most of her crew in several incidents and by disease, run aground near Kilwa (Quíloa), where it was sacked and set afire by Muslims from Kilwa, Pemba, Zanzibar, and Mafia, who had the few remaining crewmembers, but a boy, executed. The young man, together with a handful of castaways from a previous episode, debris and most of the artillery, was retrieved in the early part of 1520[8] by the ship *São Pantaleão*,[9] dispatched from India in search of the fleet. The guns had become scattered across the region and some found their way to Mombasa, from where they could not be recovered for the time being. The fate of the third galleon, the *São Jerónimo*, was in many ways even

[6]- ANTT, CC, I, 23, 82. "works of the *galeos* that are being built in Belém" is what is actually written in his receipt, incidentally by the hand of at the time clerk Simão Dias.

[7]- AGI, *Patronato*, 259, R.1. "Estos galeones no llevan ningunas mercadurías, mas que artillería e mantenimientos e van pera andar de armada en la Yndia, los quales se temien mucho de no poder yr. alla, a causa que no goviernan y el que los fizo los erró, que en ninguna manera quieren governar e por eso no mandaron en ellos ningun diñero ni mercaduría".

[8]- CASTANHEDA, II, V, XIX, and XXIX; BARROS, III, III, IX. Other sources situate the wreck in the Island of Mafia.

[9]- ANTT, CC, II, 86, 191.

Table 5.1 Galleons of the guard fleet of India - 1525

				Proposed Artillery. *CSL*, 11				Effective Art. *Frag.*, 5, 1, 9
		Built	Tonnage (*tonéis*)	Total	Chase guns	Central battery (orlop deck, except otherwise specified)	Stern	Total
Original batch	*São Jerónimo*	Belém – 1518-1519	250 350 *toneles*	–	–	–	–	–
	São Dinis	Kochi – 1518-1519	300	65 (incl.29 light guns)		24 *camelos*; 4 additional *camelos* in the half-deck; 4 add. *Camelos* in the deck's gangways; 2 add. *Camelos* in the *prepau*	2 *camelos*	Bronze: 2 *selvagens*; 5 *camelos*; 4 *esperas*; 5 *meias-esperas*; 8 *falcões*; 19 *berços*. Iron: 6 *camelos*; 2 *bombardas roqueiras*.
	São Rafael	Belém - 1519	300	56 (incl.41 light guns)	–	11 *camelos*: 8 in the weather deck 2 in the half-deck; 1 in the gangway	4 *camelos*	
	São Jorge	Kochi - 1519	150	28 (incl.15 light guns)	1 *leão*	8 *camelos*; 2 add. *Camelos* in the gangways	2 *meias-esperas*	Bronze: 1 *basilisco*; 3 *camelos*, 2 *meias-esperas*; 2 *colubrinas*; 1 *cão*; 3 *falcões*; 6 *berços*. Iron: 3 *camelos*; 3 *roqueiras*.
	São Miguel	Belém – 1519-1520?	260–300	56 (incl.41 light guns)		11 *camelos*: 8 in the weather deck; 2 in the half-deck; 1 in the gangway	2 *camelos* 2 *camelos*	–
	Santo António	Kalikhode – 1519-1520		–	–	–	–	–
	São João "Samorim"	Kalikhode – 1519-1520	150	46 (incl. 26 light guns)		12 *camelos*; 2 add. *Camelos* and 2 *meias-esperas* in the half-deck.	2 *meias-esperas* 2 *bombardas roqueiras*	Bronze: 1 *selvagem*; 1 *Espera*; 1 *colubrina*; 2 *camelos*, 5 *falcões*; 8 *berços*. Iron: 5 camelos.

(continued)

Table 5.1 (continued)

				Proposed Artillery. *CSL*, 11				Effective Art. *Frag.*, 5, 1, 9
	Santiago "Lambeamorim"	India – Ca.1522–1523	150	28 (incl. 15 light guns)	1 *leão*	8 *camelos* 2 add. *Camelos* in the gangways	2 *meias-esperas*	Bronze: 1 *serpe*; 7 *camelos*; 1 *Espera*; 2 *meias-esperas*; 2 *falcões*; 16 *berços*.
	São Leão	Portugal. No later than 1522	150–160	28 (incl. 15 light guns)	1 *leão*	8 *camelos* 2 add. *Camelos* in the gangways	2 *meias-esperas*	Bronze: 7 *camelos*; 1 *Espera*; duas *meias-esperas*; 3 *falcões*, 16 *berços*.
	"The galleon *Conceição*, which is called here [India] a galleass"	Ca.1521–1522	200–250	43 guns (incl. 22 light guns)	1 leão	16 *camelos* (incl. 4 under the half-deck); 2 more in the deck's gangways	2 *meias-esperas*	Bronze: 2 *esperas*; 8 *camelos*; 2 *falcões*; 9 *berços*.
	Piedade	Portugal – Before 1524	80–100	28 guns (incl.18 light guns)	–	6 *camelos*	2 *camelos* 2 *meias-esperas*	Bronze: 1 *camelo*; 2 *esperas*; 2 *falcões*, 12 *berços*.
	São Luís	India – Ca.1522–1524	100	28 guns (incl. 14 light guns)	2 meias-esperas	8 *camelos*	2 *camelos* 2 *meias-esperas*	Laid down; partially disarmed.

Sources: AGI, *Patronato*, 259, R.1; ANTT, *Colecção de São Vicente*, 11, fls.1–56 ["Alardo de 1525"]; ANTT, *Fragmentos*, 5, 1, 9; ANTT, CC, II, 159, 61. See also BARKER, 1996

Additional notes: *São Jorge*, *Santiago,* and *São Leão* had the same armament. The only 150 tonner to diverge from this seemingly standard ordnance being the "Samorim". *São Rafael* and *São Miguel*, besides also sharing the same notional ordnance, had their main battery installed in the weather deck, while the remaining ships had the battery under the gangways, in the orlop deck. Significantly, the word *convés* (main deck; weather deck) is uniquely used with reference to *São Rafael* and *São Miguel*. For the remaining ships, the word employed is *ponte* (gangway) and reveals the contrast between a true, more enclosing, deck, and a large open well between castles, connected by lateral gangways; and eventually an axial gangway, built upon or using the frame of the battle net (*xareta*), though not necessarily contradictory with a true deck. In fact, that seems to be the case of the duo *São Miguel-São Rafael* which had both *convés* and a gangway. The layout of the *São Rafael* and *São Miguel* is yet reminiscent of the *naus* previously used for war, which had the main armament installed in the main deck level, either in the weather deck properly or under the half deck, in the after castle. In this particular, these ships were atypical, contrasting sharply with the remaining galleons, where the battery was placed one deck lower, thus signaling the major advance towards an effective gun platform brought in with these new ships

In Lisbon, *São Jerónimo* was fitted with six anchors and a *batel* and an *esquife*, both clinker built. This ship was dispatched to Malacca, in May 25, 1525, and for that reason its ordnance is not listed in *CSL*, 11. However, the ship carried from Portugal 1 *espera*, 3 *camelos*, 2 *falcões*, 20 *berços,* and 4 heavier guns, which are impossible to identify due to the source poor condition (ANTT, *Fragmentos*, 5, 1, 9). Also absent is the armament of *Santo António*, due to its positioning to Malacca in 1521, shortly after its entry into service

The light guns were breech loaders split in two related types: the small caliber *berço* (c.50–75 mm), which was also swivel mounted, and the upscale *falcão* (falcon; c.100–120 mm), whose larger size required a bench or a carriage. Both were in fact small breech loading culverins, meaning they're relatively long. In fact, *falcões* were longer than the standard – and compact – *camelo* (camel), a medium to heavy caliber perrier. Note that caliber asymmetry is mostly the result of historical fluctuations. Evidence points out to a greater consistency of calibers within a narrower period. More than 90% of Portuguese naval artillery was made of *berços*, *falcões*, *camelos,* and *esperas*/*meias-esperas*. *Selvagem* (savage), *Leão* (lion) and *Basilisco* (basilisk) were the heaviest guns used at sea from each one of the three artillery classes, respectively: perriers, cannons and culverins. These were extremely powerful and expensive guns and therefore rare. *Selvagem* was a 265–270 mm perrier. *Leão* and *Basilisco* had the similar calibers of 170-190 mm and 170–185 mm, respectively, using metallic shot (cast iron or iron with a layer of lead), but would differ the number of calibers, considerably higher in the case of the culverins (long guns). The size of these guns prevented their use aboard in anything but chase guns or *corsia* (*coxia*) guns in galleys. There were even bigger foreign basilisks, like the R18 of Museu Militar, Lisbon, with 235 mm and 19,5 tons of weight, but designed for siege work. *Serpe* (serpent; more accurately the winged serpent of Portugal) was also a heavy culverin. *Bombarda roqueira* was a cheap wrought iron breach loader, named after its expected use as a carronade with a bundle or a canister of stone shot. *Cão* (dog) is poorly typified; considered to be a light breach loader. Very rare aboard. *Esperas* and *meias-esperas* (sphere; armillary sphere) were medium caliber cannons. Note their use as stern guard guns, intended to fight off galley attacks in scarce or no wind conditions more worrisome and a “vile tragedy” in the words of Barros.[10] The ship had the rudder wrecked by bad weather off the Cape of Saint Augustine and was forced to landfall in Brazil, where while the carpenters found timber to make a replacement, the local Indians ambushed and killed more than fifty crewmembers including the pilot. The command of the ship had been, unwisely, trusted to a Castilian nobleman exiled in Portugal, called D. Luís de Guzmán, who, furtively, had admitted aboard a large number of Castilian servants who helped him to disarm and arrest the remaining Portuguese and take control of the ship with the purpose of rebelling and going into piracy. With the opposition quashed, D. Luís took the galleon to the Azores where he captured two ships but was unable to prevent the escape of the master and several other Portuguese crewmembers who were able to attain Lisbon and give the alarm. Guzmán sailed afterwards to the Canary Islands, where he took another pair of ships and boldly bombarded the port of La Gomera. The return fire from land, however, hit and destroyed the galleon’s main yard which forced him to transfer the best of the sack and guns to the fittest of the captured ships and to abandon the galleon in the port. He was arrested upon arrival on Seville, but shortly after he escaped prison, or more probably was allowed to escape, and fled to Italy, where, as the Portuguese sources put in a moralizing and enigmatic way, he “ended meanly, as his doings deserved”, that is, suffering a violent death. Eventually, the ship and the guns were returned to Portugal. But, if the Portuguese planned to keep the details of their newer wonder ships undisclosed, the mutiny of Guzmán jeopardized those intents, for the Castilians had the *São Jerónimo* long enough for a thorough study. And If they failed to do so – which is plausible - that was a critical blunder. After its return, the galleon participated in the Savoy expedition (1521–1522)[11] and the in 1524 was at last sent to India, carrying 30 guns, as cargo or own ordnance we don’t know, and shortly after positioned in Melaka, for which reason it wasn’t listed in the gun list of 1525 which is the main source for the armament of these ships. It was, however, rated as of 250 *tonéis*, as against the 350 *toneles* given by the Castilian spy.

The disappointment – and bad omen – of the 1519 voyage was dissipated by a new attempt in 1520, which turned out to be a success, showing that the problems encountered before could not be attributed to the ships, but instead mostly to an atypical bad planning. In 1520 then, sailed the two remaining ships built in Belém, the *São Miguel* and the *São Rafael*. The sailing qualities of one of these being noted enthusiastically, by André Dias, the captain of the companion *nau Santiago*: “While I strove to come early, it took me 4 months to arrive here, due to foul weather, and we are the second ship to arrive; the first was the galleon *São Miguel*, of which Rui Vaz Pereira is the captain, who went through here twenty days ago. Do not believe Your Highness that it sails, but, instead, that it flies. I do think that great ships will

[10] - BARROS, ibidem. CASTANHEDA, II, V, XV-XVIII.

[11] - The fleet was back in Lisbon in December 1521, except for a trio of ships charged with taking wheat from Italy to city fortresses of North Africa. These included the São Jerónimo, which in September 1522 was still in Ceuta. ANTT, *CC*, I, 28, 10; ANTT, *CC*, II, 103, 102; ANTT, *CC*, I, 28, 136; FREIRE, CQ668.

come to India, if the others are alike".[12] Dias makes a mistake, however, for Pereira's ship was at this time and would be until as late as 1523 the *São Rafael*, illustrated in the *Livro de Lisuarte de Abreu* embraced by a whale, depicting a curious episode in which the ship was involved in its passage to India. Nevertheless, both ships appear to have been similar, if not twins. Both had 300 *tonéis*, had the same normative armament and shared similarities as far as the internal layout is concerned. A secondary source states that *São Rafael*'s length was 21 *rumos*, a value that would make this galleon a very long ship.

While there are uncertainties about the precise chronology of Belém's constructions, it is clear that the whole programme goes back to early 1518, eventually, albeit remotely, to late 1517. For in March 271,518, a new governor, Diogo Lopes de Sequeira, set sail for India, where he arrived in September 8th. After an overly delayed succession, Sequeira committed himself to the execution of his orders, whose main objectives were to set a foothold in the crucially strategic city of Diu and to lay the foundations for an effective alliance with Ethiopia, for which the control of Massawa (Maçuá) and the southern basin of the Red Sea were essential conditions. Among the measures taken to reinforce the Portuguese fleet, was the building of a number of galleons, one of which, a large unit, had been started in Cochin, at the time the main Portuguese base and shipyard in the East, as soon as November 1518. This was the *São Dinis* of 300 *tonéis*. A second ship, named *São Jorge* and with 150 *tonéis*, followed in 1519. Taking advantage of the demanding peace conditions imposed upon the Zamorin of Calicut by Albuquerque, back in 1512, another pair was laid down in the shipyard of Calicut in the same year, but completed after *São Jorge*, in the first half of 1520.[13] These were the *São João*, nicknamed "*Samorim*" (Zamorin), of 150 *tonéis*, and the *Santo António*, of unknown tonnage, but whose evidence point to the smaller class of 150 *tonéis*.[14] Sadly, Sequeira's instructions ("*regimento*") are missing from the archives, but it is clear that such precise timetabled and expensive constructions could not be put into practice without specific royal orders. And since those orders were delivered to him in March, the political decision predates it, to an uncertain extent; being moreover the result of a conceptual gestation lasting for a considerable time, maybe several years before 1518. One primary conclusion is to be taken from the way the Portuguese

[12] - "E conquanto trabalhei por vir cedo pus 4 meses até aqui [Moçambique] com tempos contrários e fomos a segunda nau que aqui chegou e a primeira foi o galeão *São Miguel* de que é capitão Rui Vaz Pereira, que há vinte dias que passou por aqui. Não creia vossa alteza que anda, mas avoa. Parece-me que hão-de vir grandes navios para a Índia, se os outros tais são". Mozambique, 05-08-1520, ANTT, CC, I, 26, 43, publ. *Documents on the Portuguese in Mozambique and Central Africa*, VI, 1969, pp.38–43. Our translation differs substantially from the one published, which changes the meaning of the original text.

[13] - The ships were launched in January 1520, under the supervision of D. João de Lima, the captain of Calicut and subsequently the captain of *São João*. ANTT, CC, I, 25, 128. They're simultaneously embarking supplies and finishing the rigging in March 1520 and would sail shortly after for a rendezvous with the main fleet in the Red Sea. ANTT, CC, II, 88, docs: 18, 26, 34, and 38.

[14] - Notwithstanding the fact that the existence of a galleon with the same name, built in Belém, became known in India in late 1519.

managed these naval assets in the first two years after their inception: since four ships were built in India and the other five sent there as soon as they were completed, the reasoning underlying the building of these ships was surely in the Indian Ocean.

The concept of a long-range heavy gun platform with improved gun layout and firepower and sailing qualities, solid enough to sustain damage from heavy artillery and absorb the forces of its own firing, large enough to embark a considerable number of soldiers, emerged from the shortcomings of the *nau*, the militarized merchant type the galleon ended up replacing at the core of the Portuguese fleets, and was surely present in Portuguese naval thinking several years before the completion of the first galleon. The details of the debate remains in the shadows, in parallel with the many technical changes that were put into place at the time: the introduction of the war caravel, as mentioned, or the selection of the medium to heavy *perrier* called "*camelo*" as the standard gun of the Navy, being perfect examples. We do know, however, that the years before 1518 and afterwards were marked by the growing dissatisfaction with the available sailing vessels, the *nau* and the traditional caravels, the lateen and round variants. Their shortcomings, the result of being merchant vessels converted for war, had become more and more notorious as the Portuguese arc of operations in the East widened up and their many contenders, recovering from the initial disasters, started to adapt with new equipment and tactics. The caravels were too small for fighting and for long-range operations. The *naus*, their general mediocre nautical performance aside, were highly vulnerable to galley attacks in anchorages or during the lulls and dying out of the winds, so frequent and sudden in the coastal regions of the Indian Ocean. Their architecture was not suitable to improve the gun layout towards the desirable 360° arc of fire, essential to fend off these galley attacks and much else. Their fire coverage was full of blind spots, all of which were well known and willingly exploited by the Portuguese antagonists, for they were structural. One conspicuous fault was the lack of antiship guns in the prow, whatever the angle, for the highly sloped decks in that part of the ship prevented it, making the forecastle in *naus* useless as a gun platform. And the rest left much to be desired: the ship's firepower was placed too high, in the main deck, half deck, and quarter deck, meaning that these guns could hardly be used to fire at sea level ("*ao lume da água*"), sometimes with the shot ricocheting on the surface of the water - "*chapeleta*" (Barker 1998), a firing procedure perfected by the Portuguese from the late fifteenth century on, which became one of their tactical signatures, and the main reason behind the high rate of enemy ships sank by gunfire alone, including European built ships, achieved by their navy since the early sixteenth century. Furthermore, the *naus* hulls were vulnerable to medium artillery fire and above and there were reports that the ships could not stand their own fire for too long before starting to leak, sometimes suffering structural damage. Galleons were the envisaged universal solution to all these deficiencies.

There was still another reason for the inception of these powerful warships. The Portuguese were distant observers, occasionally familiar, with the three types of galleons that were around in the turn of the century. Aside from some solitary pirate, the Portuguese did not use those ships, but they recorded their appearances on an ordinary basis, for they were commonplace on the Mediterranean Sea.[15] That is why, catalogue errors aside, Portuguese primary documentation previous to 1518 is full of galleon's references, though none of them associated to the Portuguese variant. These were systematically absent from Portuguese fleet's inventories and orders of battle pre-1518. Unfortunately, the comprehensive scrutiny essential to identify both Portuguese fleet compositions and the true nature of these previous galleons is very recent (Pissarra 2002, 2016), as it is the approach to Portuguese naval and shipbuilding history in its wider European framework. In other words, to fully understand the significance of 1518 and the singularity of the Portuguese variant we need to perceive it within its proper background: the general history of the galleon and naval warfare development.

These pre-1518 references fall, without exclusion, into one of three types of ships or boats named galleon, all of them Italian in origin. The first of which was a medieval, very small to small, oared ship that is reported in Genoese sources from the twelfth century on, first under the Latin form *galeonus* and later in Ligurian as *galeone*.[16] Note that this Latin form may not necessarily be the original, but instead just the erudite translation of the vernacular form, which is highly plausible. Regardless of the forms, *galeonus* or *galeone*, the word means nothing more than small or tiny galley, where the connotation of the suffix is reversed from augmentative into diminutive or, more properly, to a derogative meaning. This phenomenon occurs in Portuguese language as well (e.g. *escotilhão* – small hatch), although the Portuguese word *galeão* is just the transcription of the Ligurian *galeone*. Note that there is a strong affinity between Portuguese and Ligurian languages, particularly in nautical vocabulary. To this group belongs at least one of two Genoese galleons captured by the fleet of D. João de Meneses in 1501 and which caused so much speculation since reported by Damião de Góis in the 1560s. In effect, according to primary evidence (Aubin 2006, pp. 144–145; Pissarra 2016), one of the ships was in fact a brigantine, while its companion was indeed a galleon, albeit of a unspecified type. Nevertheless, both sank in transit when the fleet was returning to Portugal, having thus no influence in the development of the Portuguese galleon. That the word galleon was used as a synonym of small, oared ship in Portuguese naval parlance is a fact, although it seems more like an outmoded trait of certain individuals than widespread speaking, falling out of use before 1520. One of these personalities being no less than Afonso de Albuquerque, who claimed to have been attacked by 200 galleons off Ormuz in 1507.[17] These were actually *terradas* and *terranquins*, watercraft typical of the Eastern part of the Persian Gulf (Nance 1914, 1920; Pissarra 2012). More enlightening is perhaps an order by Pêro Ferreira Fogaça, captain of

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[15] - Maria Alexandra Carbonell Pico refers to the occurrence of the word galleon before the sixteenth century only twice, both in the thirteenth, and without any description or details about their size and shape.

[16] - In addition, Auguste Jal mentions a document from 1285 in which the designation "galleon" appears to refer to a 16-bank rowing vessel, with two oars per bank.

[17] - BNP, cod.11.353, fls.171–177 (SMITH, 1992); Biblioteca Riccardiana, Florence, cód.1910, fls.125–130; BGUC, cód. 475, fls. 140v-143r.

Kilwa, dated April 1506, to deliver the materials required to complete the fitting out of the galleon *Santiago*. Fortunately, the companion receipt clarifies that the vessel was in fact the brigantine *Santiago*, newly built in situ, to serve the role of general duty vessel attached to the fortress.[18]

The second type of galleon was a boat, a river or harbour duty vessel, which the Portuguese associated with Rome: "*galeões de Roma*". They are mentioned by Garcia de Resende as the only ship type with the latten rigging required to sail forth and back from the gulf of Guinea, besides Portuguese latten caravels, albeit too small for such a voyage.[19] They are quoted again in 1514, for the reason that Nicolau de Faria, the man in charge of the elephant presented by Manuel I to the Pope Leo X, had to enforce one of these galleons in Porto Ercole in order to unload the animal.[20] The state papers from India, between 1510 and 1513, contain references to two galleons. These were indeed Portuguese vessels, although they never occur in any fleet roster of the period; therefore, they require a comment. One was being built in 1513 as a private undertaking of a settler from Goa, to whom Albuquerque granted a small portion of cotton fabric to make a sail for the galleon.[21] It is likely to be a boat, which fits into the second type. Unfortunately, disambiguation is impossible here, for there is just a solitary reference. The second galleon, also named *Santiago*, appears in early 1510, and in this case it seems to have been a ship-size vessel, probably a sailing ship, for it had a purser and a master, instead of a *comitre* (which would be the case if it was an oared ship),[22] even though it was manned by a crew of only four men; however, this was almost certainly a skeleton crew.[23] A possible explanation is *Santiago* being one of the 200 *botte* galleons that the Portuguese took from the Mamluks at the battle of Diu, in February, 1509. While the majority of the Egyptian fleet was captured and integrated into the Portuguese fleet, most of the ships had a short-lived service; it is even doubtful if the majority became operational again. In fact, only the flagship, a carrack of 500 *botte*, according to a report echoed by the Venetian merchant and diarist Girolamo Priuli, had a relatively lasting career. This brief existence could explain their absence from the fleet rolls, taking into account the Portuguese operational timetable sequential to the battle.

[18] - ANTT, CC, II, 11, 7.

[19] - RESENDE, CL, p.379.

[20] - ANTT, *CC*, I, 15, 3.

[21] - ANTT, CC, II, 37, 119.

[22] - *Comitre* was the chief rowing officer and, in the case of Portuguese oared ships, also the ship's master. Unlike private ships, where the master was the skipper and often the owner and pilot of the ship, royal ships had captains appointed. These were primarily the king's representatives, but in many instances, especially in warships (for the king of Portugal had merchant ships as well), they would act as effective commanding officers. In this condition, the master was the chief seamanship officer and the principal of the seamen; navigation excluded, as it was the pilots' responsibility. While pilots had a higher social and professional status and in general were deemed more important than masters under sail, it was the master who was accounted for the ship before the naval administration, in the absence of the captain.

[23] - ANTT, *Contos do Reino e Casa*, *NA* 595, fls.9–13; ANTT, *CC*, III, 4, 7.

Howsoever, these ships had at best an abstract influence on the development of the Portuguese galleon, as we will discuss next.

The third type is by far the most significant of the three and in many ways the forefather of all the succeeding variants of the sailing galleon, beginning with the Portuguese one. The type was extensively studied by Luciana Gatti and Furio Ciciliot (Gatti 1975, 1999; Ciciliot 1993, 2000, 2005). This was usually a small sailing ship that emerged in Genoa in the late fifteenth century and swiftly spread across the Mediterranean Sea and beyond.[24] In a few years, it could be found sailing to Antwerp from Ragusa or sailing along the Eastern shores of the Peninsula or in the Levant, from where, through Egypt, it passed into the Red Sea and came into direct confrontation with the Portuguese naval forces in the Indian Ocean. The type was a versatile light sailing ship that could be used for war like any other sailing ship, given the proper fitting out. Even so, within the galley fleets of the Mediterranean, their role was restricted to that of auxiliary or transport. The ships that the Mamluks took into the Northeast of India in a naïve attempt to expel the Portuguese from India were built in Suez with foreign assistance, very likely European, and were fitted for front line combat. These were small ships of between 100 and 120 *tonéis*[25] slightly above the type average tonnage. However, there were larger examples, like one belonging to a Ragusan merchant, of 250 *tonéis*, whose wreck in the mouth of

[24]- According to Furio Ciciliot, from 1481 until the mid-sixteenth century, the galleons built in Varazze and Savona undoubtedly belong to a perfectly defined typology, whose light characteristics made them desirable in the Mediterranean (that is how in 1501 the village was contracted to build a galleon for King Louis XII of France).Varazze's galleons had a 4:1 length to beam ratio, bow and stern castles, and a ram that was sometimes triple. A type of ship with a triple ram appears in a painting by Domenico Ghirlandaio, *The Adoration of the Magi*, from 1488 at the Ospedale degli Innocenti in Florence – in three similar versions, with slight differences. Initially small - referred to, for example, as *galeonum seu* (or) *sagitta*, until 1501– Genoese galleons grow during the sixteenth century and their shape evolved to something closer to that of the larger merchant ships.

Auguste Jal refers to the existence of galleons in northern Europe in the early sixteenth century, referred to in Jean d'Auton's *Chronicle of Louis XII*, which reports the loss of a considerable number of vessels of a Flemish and German fleet described as "3 ships and many galleons", on the coasts of Spain, in a storm. These ships, if not boats, seem to have been very small sailing vessels, like the majority of early sixteenth century galleons.

[25]- According to an information that reached Girolamo Priuli in March, 1506: *per le predicte lettere dal Chagiero se intendava il sig. Sultam preparava galion 4 de botte 500 l'uno et barze 2 de botte 200 l'una, gallie 2 sutil et fuste 3 de banchi 28 l'una et uno bregatin, tuto benissimo in ordene, armate di magrabini, turchi et altri valenthomini et* cum *artellarie assai*. PRIULI, *Diarii*, p.405. We are persuaded that Priuli's informer mixed up the tonnage of the *barze* and the galleons, for Portuguese sources, while in general endorsing the ratio of 4 larger ships to 2 smaller ones and reporting the presence of galleons, place the latter among the smaller ships, unlike Priuli's report. It is worth to restate that the Portuguese captured the entire Mamluk fleet, bar the vice-admiral which was sunk by pointblank gunfire. The spoils including the flagship which, henceforth, in Portuguese service, was classified as a *nau*, while, according to Priuli's report and as the larger ship of the fleet, it had inevitably to be a galleon. Depending on the equivalence criteria between the *tonel* and the Venetian *botta*, 1:2 or 3:5, 500 and 200 *botte* can be converted into approximately 250–300 *tonéis* and 100–120 *tonéis*, respectively.

the Scheldt was reported in 1512 by the Portuguese factor in Antwerp[26] or the very large Turkish galleon of 800 *botte* presented to the Mamluk sultan by Bayezid II in 1512 and duly captured by the hospitaller fleet under the command of the Portuguese knight André do Amaral.[27]

In addition to the shortcomings of *naus* and small caravels, mentioned above, the increasing reports and contacts with these ships persuaded the Portuguese that building their own galleons was the best course of action to deal with the new threat, while having the additional benefit of greatly improving the fighting capabilities of their fleet's sailing component against oared ships. This latter problem could only be solved with the construction of a large and combined oared fleet, a task they took in hands in synchrony with the building of the new sailing ships, and whose significant story belongs to another chapter.

However, effective measures to bolster the oar power of the fleet had been in force for several years and these became providential circa 1518, insofar as they granted Portuguese shipyards with the know-how to build their own galleons. The attempt to create a strong and homogeneous galley squadron to operate in the Indian Ocean led the Portuguese Crown to search abroad for skills that were scarce or nonexistent in Portuguese yards, circumscribed as they were to the building of sailing ships. The obvious place was Genoa, whose skilled labour and maritime culture has had a strong influence in Portugal since the Middle Ages and whose relations – usually at personal level - posed a very moderate political danger. In fact, as the studies of Richard Barker, besides our own research, clearly confirm, the Genoese connections were far more influential and operative in Portugal than any Peninsular link, even if the Portuguese were ready to recognize the relevance of Biscay in maritime affairs. Accordingly, back in February 1513, a commercial agent of Manuel I, Lopo Carvalho, hired a considerable number of galley officials (at least 22, including eight shipbuilders), from Genoa, Savona, Monte Alvo, etc. (Ciciliot 2000), and, proceeding with his mission for at least two more years, he went on to acquire large quantities of assorted galley related materials, including sails, rower chains and almost 1800 oars for galleys, brigantines, galleons, and galleasses. Several of these parts, bought in small quantities, were noticeably intended to serve as templates. The Genoese hired by Carvalho started to arrive in India in late 1515, where they found an already well-established group of Corsicans, led by the Renaissance man and flamboyant Silvestre de Bachon, "The Corsican", who had first reached India by its own initiative and adventurous spirit and was later backed by Manuel's royal favour. The group was in fact him, his many brothers, and a few other Corsicans and no sooner the two groups were clashing for professional pre-eminence and royal favour. The lead personality among the newcomers was a certain master Vinel (or Vumer; Vimier), to whom the governor Diogo Lopes de Sequeira officially referred to in 1519 as sent to India to build galleys and to come highly recommended by the king. He then adds that Vinel was currently building the galleys and the galleons

[26] - ANTT, *CC*, I, 9, 133.

[27] - ANTT, *CC*, I, 11, 47.

that he, the governor, ordered to be built. By this time, Silvestre was no longer in India. He left his brothers behind and returned to Portugal – where the rest of his family had settled – after a violent altercation with Lopo Soares de Albergaria, Sequeira's predecessor, in the aftermath of the failed Portuguese attack against Jeddah, in 1517. In the summer of 1518, supplies were being delivered to him in Algés, adjacent to Belém (and therefore to the yard where the metropolitan galleons were being build) and later João de Barros would record that Silvestre became highly regarded in Portugal, after his return from India, for his work in building oared ships and galleons.

This is enough to support that the Genoese had a most relevant part in the first stages of the entire process, even if many details and the exact measure of that input remains to be fully understood. Certainly, the resulting Portuguese ships emerged with significant differences regarding their Mediterranean relatives. For a start, the Portuguese galleons had a much higher average tonnage. The ships of the first batch were divided into two proportional classes of 150 and 300 *tonéis*, both corresponding to a given number of crewmen and guns, if the criteria applied in other better documented circumstances were used in this instance. We know that *São Dinis* was designed to have 25 heavy guns, though (the uneven number suggests a chase gun). Just a few years later, the Portuguese would introduce a new class of around 100 *tonéis* (see *Piedade* and *São Luís*, Table 5.1), which became popular during the first half of the century. Some being the result of the rigging modification of war caravels, which effectively were no more than small lateen galleons. Circa 1530, they moved in the opposite direction with the building of the larger and extremely powerful *São João* setting up the practice of building one such ship for the Atlantic fleet every 10–20 years. The 1574 *São Martinho* of 600 *tonéis* and Armada fame was an offspring of that routine. In late 1518, Pedro de Bastroni "The Corsican", the eldest brother of Silvestre, left us a set of dimensions relative to a Portuguese galleon which had been built at Cochin, although neither Pedro nor his brother were involved in its construction. This was a larger ship and therefore *São Dinis* (the alternative being the 150-ton *São Jorge*). Unfortunately, the document is irretrievable damaged by a hole in the paper that destroyed several words in this critical part of the text, even if some remaining letters allow us to reconstruct a portion of it. Bastroni uses Genoese measures: *goas* (c.0.75 m) and *palmos de goa* (c.0.25 m); maybe *côvados* (0.66 m) for the ship's length. This is longer than 50 *goas* or *côvados*, while the breadth is wider than 30 *palmos de goa*, probably 36 or three times the depth, which was 12 *palmos de goa*. Regardless of the many variations possible, this was a very long ship, with a length of more than 30 metre and a very high ratio between length and beam, between 1:3.66 and 1:4.1, if the length was longer than 50 *goas* (Pissarra 2016).

While laying down their own galleons, the Portuguese kept meeting Mediterranean galleons at sea. In fact, in 1518 there was, to a certain degree, a galleon's paranoia in India with galleons being reported as being built along the Western Coast of India, in support of an expected renewed Mamluk offensive. At the time, the Portuguese were still unsure about the dramatic changes in Egypt and the fall of the Mamluk Sultanate at the hands of the Ottomans. They knew that the rebuilt Egyptian fleet had galleons as well, for during the unsuccessful Jeddah operation they had set afire to a large exemplar belonging to that enemy fleet. In India, the Zamorin of Kozhikode, breaking the peace conditions accorded with Albuquerque back in 1512, had one built secretly in the port of Ponnani (Panane), with the technical oversight of two Rûm. Eventually, the Zamorin was forced to hand over the ship to the Portuguese who incorporated it into their own fleet. Firstly, classified as a galleon but shortly after and henceforth as the *navio São Simão* "Panane", according to the curious but significant practice of classifying foreign incorporated galleons (named as such as long they were used by others) as *navios*, to tell them apart from their own "true" galleons. They acted similarly towards galleons from Biscay, whenever one of these ships was chartered or bought second hand, which occasionally happened towards the middle of the century, adding a necessary toponymic: *galeão biscaínho* and using them for trade or transport service.

This introduces us to perhaps the most significant of the new ships' features. They were built for war and throughout the century overwhelmingly built and owned by the state; residual numbers being found in private hands. And they were very powerful and capable ships, much more than any previous sailing ship used for war. Thus, being a serious contestation of galley predominance in war at sea and a major step in the evolution of the warship in general. Nothing is more symbolic of this change than *São Dinis* taking over the role of flagship of India immediately after its completion, a position it kept for ten years until being replaced by a similar galleon, purposely built to replace it.

Iberian galleons developed along different lines. Portuguese galleons have always been warships, even when the shipping crisis acutely felt in Portugal from the late sixteenth century on, forced an increasing number to be diverted to transport and cargo service, namely in the India route. In Spain, Mediterranean sailing galleons, probably from the Genoese pattern, were used as early as 1509, when one of these vessels took part in the Armada that conquered Oran in May of that year. Prior to this year, all references to galleons in Spain refer to fishing boats, which were not fully decked, on the north coast, and to small rowing vessels on the south coast. A location of indigenous development was Biscay, one of the most important seafaring regions of Europe. There, a versatile type of galleon, used in a wide range of tasks, including long distance fishing, emerged. The ships were of moderate size: an example, the *San Juan*, lost in 1565 in Newfoundland, was built on a 14.75 m keel. However, they were strong enough to be considered India route capable by the Portuguese, who, as mentioned before, used them, albeit sporadically, in that demanding route. They formed the basis for the next Spanish development: the Spanish galleon of the Indies. These ships were introduced in the middle of the century as oceanic escorts and second role cargo ships to address the vulnerability of the American routes with a continuous escort. They were never satisfactory. After the annexation of Portugal, in 1580, the Spanish came into direct contact with the Portuguese galleon. However, eight years later, Portuguese and Spanish galleons were still very distinct types. The organization of the Armada of 1588, a showcase of Southern Europe shipping, leaves no doubt about it. Gradually, through a process yet unknown, the two types converged, until becoming virtually identical to the naked eye, albeit keeping some structural and internal layout differences.

The galleon spread fast across the Atlantic coast, from where is not known. Popular culture associates galleons with Spain, but in reality, the French, the Scots and the English, not to mention the Portuguese, all had galleons before 1550 - and for that we mean full sailing galleons, of moderate size, purposely built for war. Steadily increasing in size, strength, and firepower galleons became the mainstay of all Atlantic navies. In the seventeenth century, giants of more than 1000 tons and 60 medium to heavy guns were not uncommon. Small galleons remained popular, albeit proportionally larger than their forerunners, some hidden behind new names or belonging to subtypes, like *pataxos* or *galeoncetes*. There were also hybrids, with an oar system, such as *galizavras*/*galizabras*. Regional evolution of the galleon gave way to new types of ships even before 1650, like the frigate. In turn, large warships of the eighteenth century were the result of the evolution of large late seventeenth century galleons in France and England.

The remaining Portuguese ship types alike, technical documentation on the Portuguese galleon dates from the Spanish Period (1580–1640), thus is of little use in documenting the earlier stages of the galleon's development. Iconography is also late, relative to 1518, with the earliest acknowledged depictions produced within the period 1540–50. The earliest of these are the drawings made by D. João de Castro, later viceroy of India, between 1541 and 1543, to illustrate his own *Roteiro do Mar Roxo,* being an itinerary of the 1541 Portuguese expedition to the Red Sea against the Turks, in which Castro took part. Particular note should be made of the plate "Tábua da Aguada do Xeque" relating to Bandar Debeni, in Socotra Island,[28] in which two galleons and two *naus* pose and contrast sharply. The galleons are longer ships with Bonaventure sails and lower works. Both ships have gun decks and their castles are fully protected by pavises; a battle net frame is present in one of them. Of particular interest is the forecastle, which is reminiscent of a bulwark, strictly contained within the limits of the stem, unlike the *naus* where the castle protrudes above and beyond the stem, as a logical evolution of the Middle Ages platforms for archers and men-at-arms. The bulwark like forecastles have similarities with the *arrombadas* found in contemporary galleys and used as gun platforms. Betraying their galley origins, both galleons have rams, topping the stem and being supported by a cut-water or false stem. However, just like in modern galleys, these rams served no function associated with ramming, being too weak and placed too high for that purpose. Even in galleys, the only tactical use of these structures was to serve as a walkway in boarding assaults. Rams had a martial symbolism, though, and were an architectural choice, among other possibilities, to best finish a long ship, helping to resist pitching and to secure and balance the rigging. Unrelated to Castro's drawings but significantly depicting a very similar Portuguese galleon are the magnificent and gigantic watercolours painted by Jan Vermeyen and Pieter Coecke van Aelst between

[28] - CASTRO, D. João, "Tábua da Aguada do Xeque", *Roteiro do Mar Roxo*, 1543, British Library, *Cotton*, *Ms. Tiberius*, D.IX.

1546 and 1550[29] as the base cartoons for the manufacture of the Tunis tapestry series commissioned by Charles V to celebrate his victorious expedition against the city in 1535, at that point the main base of Hayreddin “Barbarossa”, in which a strong Portuguese naval squadron took part, led by the great galleon *São João*, built c.1530 as the first example of a very large Portuguese galleon. While there are many myths surrounding the ship and its armament, analysis of State Papers leaves no doubts about the massive armament of maybe more than 200 guns that the ship embarked for the expedition (Pissarra 2002). As a side note, Castro was part of it, as the commander of one of the 20 participating war caravels and was latter, in 1543, entrusted with the command of the same *São João* (de Jesus 2016). More importantly, Vermeyen, who Charles brought in his entourage with the purpose of making the necessary sketches, was an eyewitness of the attack. The galleon is represented twice, curiously with some differences in the aftercastle. The slender ram contrasts with the massive shape of Castro’s ship and the aftercastle gives a more built up impression but, apart from the scale and the multitude of guns, is essentially the same profile. The resulting tapestry series, made in Brussels by Willem de Pannemaker between 1548 and 1554, was copied to printed format by the famous engraver Frans Hogenberg from Malines, at an uncertain date, and afterwards reprinted several times. When Hogenberg started working on the engravings of Georg Braun’s *Civitates Orbis Terrarum*, he recycled the galleon to illustrate the plate relative to Lisbon, which appears in vol. 1 published in 1572.

Bonaventure sails as typical of Portuguese galleons and a distinguishing feature in comparison to *naus* is an old and flawed idea. Bonaventure sails had to do, more than anything, with the length of the hull, specifically the after deck, which would comprise more than half of the ship’s length. One should note that the main mast position would be immediately forward the fore extremity of the half castle, therefore beyond amidships, thus leaving a large area aft void of sail, where two lateen sail masts could be installed instead of one. The bigger the ship, the bigger the mizzen and more pressing the necessity to split an oversized sail – and the amount of work and time consumed it would imply – in two. Very large lateen sails were used in galleys, but these ships had a much larger workforce than any sailing ship, for the rowers were used in all ship’s work. Therefore, large ships tended to have Bonaventure sails, regardless of the type. That is why they are well represented in the iconography of the large carracks of the India Run while being inconsistent as far as galleons are concerned. Notwithstanding the fact that galleons were longer than *naus* in relative terms, one should remember that the vast majority of Portuguese galleons was, until the last quarter of the sixteenth century, made of ships of modest dimensions, usually no larger than 300 *tonéis*, and that a considerable portion of that was made of small ships, around 100 *tonéis*, in which Bonaventure sails were essentially an option.

[29] - Jan Cornelis Vermeyen e Pieter Coecke van Aelst, ca.1546–50, Kunsthistorisches Museum, Viena, Gemäldegalerie, 2043.

8 Galleasses

There is enough evidence from the first half of the sixteenth century to support the proposition that the word galleass was used either as a synonym of galleon or to name a subtype of war galleon, alongside its traditional meaning of reinforced galley. The first example to be considered is the galleass *Conceição* of the Portuguese Fleet of India (see Table 5.1), classified in 1525 as both a galleon and a galleass depending on the viewpoint. The ship is well documented in primary sources (essentially administrative papers) and from these we know that it never had a rowing system installed or embarked oars or any part related to that system; the same being true for rowers and their provisions. Furthermore, the details of its operational career expose an operational and tactical use not different from the other galleons of the fleet, with which it invariably formed a long-range heavy squadron. Likewise, Auguste Jal, back in 1848, when studying the papers related to the two galleasses which Francis I included in the dowry of his daughter, Madeleine de Valois, married with James V of Scotland in 1537, looked in vain for details related to their oar system (Jal 1842). One of these ships was captured by the English in 1544 and therefore is represented in the *Roll of Anthony* from 1546, as the galleass *Salamander* of 300 English tons. There are no signs of an oar system, quite conspicuous in the four oared galleasses depicted in the roll: for instance, *The Bull*. Besides *Salamander,* there are four more oarless galleasses portrayed, which are nothing more than galleons. The roll presents us with an excellent juxtaposition between two completely different types of ships obscured by the same designation. That the word galleass was frequently used to designate galleons is furthermore reinforced by the following passage concerning Portuguese galleons of the Atlantic fleet: "The said ship was one of the king's galleasses [the king of Portugal], about the burden of four hundred *tunnes*, with about three hundred men in her, the ship being well appointed with brass pieces, both great and small, and some of them so big that their shot was as great as a man's head […]" (Hakluyt 1904, vol. VI, pp. 266–284). Worthy of mention is the fact that the Indian built galleons belonging to the early batch had *comitres* appointed instead of masters. Again, this demonstrates that none of these ships had a rowing system; eventually that short-lived practice could be related with their Genoese background.

9 Pinazas

According to Carbonell Pico the name seems to originate from northern Europe and in the thirteenth century *pinaças* - which are referred to in the Foral of Vila Nova de Gaia: "*naues et barce et nauigia that fuerit majora quam pinatia*" - were small ships, used for fishing and salt transport.

Casado Soto mentions an interesting document, dating from 1522, that refers to "five *chalupas nuevas en astillero 'de madera de roble and terminal tingladas* 'of 35 to 40 tons, three pinazas '*calafatadizas* and also of oak, with up to *40 toneles y otras ocho 'tingladas'* built of oak and with *'35 to 40 toneles'*, that is, two types of *pinazas*, some carvel built, and others lapstrake built. The document concludes: "all *chalupas* are shallow vessels, made for the fisheries of the Kingdom of Ireland and of Andalusia". This text seems to include *chalupas* and *pinazas* under the designation of *chalupas*.

At the end of the seventeenth century Veitia Linage writes that "the Pinazas that are used in the sea of Cantabria are about the size of the g*avarras* of Seville, although with some differences in the construction and generally not as big".

It is impossible to know if the Portuguese *pinaças* were similar to those of Biscay, but Auguste Jal mentions *pinazas* as being small or medium sized vessels.

At the end of the seventeenth century the term pinnace designates in northern Europe a type of ship similar to the *pataches* of the early part of that century, flying three masts and similar to the Dutch *jachts*.

10 Pataches

The dictionary of Leitão and Lopes says that *patacho* was - in the nineteenth century - a two-masted ship, with square sails on the foremast and tops, and a square and lateen sail in the mizzen. On the prow mast he left a rack, velacho, bunion, and above, and on the aft mast a fore and aft sail and a triangular lateen. The old *patachos*, at least those of war, mounted three masts, possibly ship-rigged, had fore and stern castles and a battery on the weather deck. There were reports of *patachos* mounting 18 to 26 pieces.

According to Veitia Linage, "*pataches* were the generic name of the small vessels that sailed in an armada, distributing messages, sounding, and performing other tasks the general might order". Jal states that the *patachos* were exclusively warships for a long time.

In 1616 Manuel Fernandes included three *patachos* in his *Livro de Traças de Carpintaria*: regiment for a 100-ton *patacho*, and *regimento* for a 100-ton *patacho olandes*, whose regiment says "this *patacho* is a warship" (folios 14v. And 15), and a set of drawings for a *patacho de guerra* (folios 103v. And 104r.). A set of drawings for a "foreign *patacho"* was added to the book, drawn with a different ink on a sheet that appears to have been inserted in the codex later (folio 113 and between folio 113 and folio 114). This foreign *patacho* is longer and lower.

When we consider the measures indicated in Fernandes' regiments, the difference between the two drawings are evident. The Portuguese *patacho* has a length overall of 26 m and a beam of about 7 m, which gives a LTBR of 3.75. The Dutch *patacho* has two decks and is shorter, with about 20 m of length overall and 6 m of beam, which gives a LTBR of 3.4. The drawings are not to scale, but the overlap of the silhouettes of these three ships, after being drawn at approximately the same scale, suggests that the Dutch *patacho* has a shorter spring of the stem than the Portuguese, which is lower, as indicated in the respective regiment. The third, foreign *patacho* is larger and its silhouette resembles vaguely that of an English galleon.

11 Frigates

Like galleons, it is possible that the origin of small fishing and transport frigates, as described by Manoel Fernandez in his *Livro de Traças de Carpintaria*, is Italian, as the word already appears in Boccacio's *Decameron*. In the Mediterranean, fifteenth and sixteenth century frigates appear to be lighter versions of *galea* - immortalized in Lepanto - but seventeenth century war frigates seem to have a completely different origin.

In Spain, the sixteenth century frigates were also small ships, as Garcia de Palacio explains to us when he mentions the *fragatas* that should not have more than 50 tons of capacity. This ambiguity between the war frigates and the smaller vessels has remained to this day, where the word *fragata* refers both to the Tagus tenders and the Portuguese Navy frigates. But at the end of the seventeenth century José Veitia Linage wrote: "Frigates, which is the name that designated both those of Spanish and foreign design applies to the large warships used nowadays".

These large warships, made for war, were shallow, nimble, and well-armed ships, usually with a battery on the weather deck and in the castles. Its origin is usually attributed to the fleet that in the late sixteenth century Martín de Bertendona drove against the Dutch from Dunkirk.

The so-called Dunkirk frigates appear to have been light, agile, and fast warships. The first of these frigates may have been the *St. Albert*, with 160-ton and 16 guns, commanded by Antoine de Bourgoigne, whose nautical characteristics were tentatively transferred to two warships built in Dunkirk in 1600, which appear to have been the first Dunkirk frigates. By 1620 designs of Dunkirk frigates, developed from the model of the ship *St. Albert*, were used by all naval powers in northern Europe as ideal ships for privateering. In the mid-seventeenth century frigates were ships with one or two batteries, low fore and stern castles, three masts, and entirely designed for war. One of the first to be built in England - for privateering - was the famous 32-piece, 315-ton *Constant Warwick*, designed by Peter Pett and completed in 1645.

In the second half of the century, warships were classified according to crew, number of cannons, or length of battery cover, and frigates acquired their own status as warships.

In Portugal there is some published information on seventeenth century frigates, namely a small number of late regiments, dating from 1692, for the construction of frigates between 11 and 21 keel courses. However, seventeenth century naval iconography is scarce and poorly studied, and it is difficult to find good representations of Portuguese frigates during this period.

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Chapter 6
The Iberian Peninsula Between Two Seas: Shipbuilding Revolution in the Mediterranean and the Atlantic Ocean, Fourteenth to Fifteenth Centuries

Marcel Pujol i Hamelink

Abstract There were two naval traditions in Europe during the High Middle Ages: the Baltic-Atlantic and the Mediterranean. They both connected in the north of Portugal. The opening of the maritime route which connected the Mediterranean with Flanders was the turning point of the Naval Revolution which started at the end of the 13th century. The technological exchange took off at that moment (the way the ships were built, the different types of sails and rudders) and that highly influenced the Mediterranean navy in the 14th century and the Atlantic navy in the 15th century.

1 Introduction

Historiography usually gives the name of 'revolution' to a historical moment that caused a great change at the social and economic level (the Neolithic Revolution, the French Revolution, the Russian Revolution), but also in many cases the term is associated with a technological change (the creation of tools in stone, fire, metallurgy, industry, computing, etc.). A series of milestones that mark a before and after, and that serve to frame the eras or historical periods. Our field of study chronologically covers the Middle Ages, in which it is usually taken as a reference from the beginning of the Middle Ages with the fall of the Western Roman Empire (476) and the end of the Middle Ages with the fall of the Eastern Roman Empire or Byzantium (1453). In our case and, taking into account that we are talking about maritime history and specifically about naval technology, there are two dates that practically coincide with those usually used by historians.

M. Pujol i Hamelink (✉)
Escola Superior de Conservació i Restauració de Béns Culturals de Catalunya, Barcelona, Spain
e-mail: mpujol12@xtec.cat

A. Crespo Solana et al. (eds.), *Heritage and the Sea*,
https://doi.org/10.1007/978-3-030-86460-6_6

The first, the sixth century, when there was a naval revolution in the Mediterranean with the use of a new constructive principle, that of skeleton-first construction, which would gradually prevail over the previous hull principle that had been in use for more than 2000 years (Pomey et al. 2012). The substitution of the shell-first principle (with the planking joined by mortises, tenons, and treenails or well sewn) and the generalization of the skeleton principle (with the planking nailed to the frames and caulked), it is considered a fact from the eleventh century (Steffy 1982). The second date that marks the end of the Middle Ages—from a maritime perspective—can be considered the first voyage of Christopher Columbus to America in 1492.

In the Atlantic area, the crisis of the Western Roman Empire led to the entry via the northern border of different Germanic peoples from the fourth century, by land and also by sea. In this case, what occurred was a diffusion of naval technology from the Baltic and the North Sea to the coasts of what was then the Atlantic Roman Empire: *Britannia*, *Gallia,* and *Hispania* (English Channel, the British Isles and following the coast towards Cantabria and the north of Portugal). In this case, the construction of the Greco-Roman shell-first hull will be replaced by a construction system that uses the same principle (shell-first) but with lapstrake planking.

The diffusion of the Baltic-Atlantic naval technology and the diffusion of the Mediterranean have their meeting place on the Atlantic coast of the Iberian Peninsula, and it seems that over time the limit of these two technological worlds in the north of Portugal has been consolidated in Porto (Lixa Filgueiras 1991). In the Atlantic area, Anglo-Saxons, and later, Jutes, Frisians, and Vikings end up consolidating this technological space, while in the Mediterranean the new construction principle (skeleton, and also the use of the lateen sail) spread and became generalized, thanks to the Byzantine and Muslim navy in its expansion into the Western Mediterranean. Presumably, the arrival of the Muslims to the Iberian Peninsula (711) and their expansion by land, but also by sea, along both the Mediterranean and Atlantic coasts, consolidated the use of Mediterranean naval technology in the areas that became al-Andalus. This border remained more or less stable for more than three centuries: on the Mediterranean side in Barcelona (conquered by Charlemagne in 801) while Tortosa remained on the Muslim side (until its conquest in 1148) and on the Atlantic side the basin of the Douro River was conquered by Alfonso I of Asturias (741–757), establishing the border for a few centuries in Porto (Coimbra was conquered in 1064 and Lisbon in 1147) (Fig. 6.1). If the Mediterranean border between al-Andalus and the Carolingian Empire was political, it was not from a naval view, since the same technology was shared. The Atlantic border between al-Andalus and the Christian kingdom of Asturias, was not only political but also naval, as the Atlantic naval technology consolidated to the north of this limit, while the Mediterranean naval technology prevailed to the south of the Douro (Lirola Delgado 1993).

Although geographically the Iberian Peninsula divides its coasts between the Mediterranean and the Atlantic by the Strait of Gibraltar, these in turn can be subdivided into the Catalan-Valencian coast and the eastern-Andalusian and Murcian coast, and on the Atlantic side into the Cantabrian coast, the Galician-Portuguese coast, and the Gulf of Cádiz. From a technological point of view, its coasts can be

Fig. 6.1 The Iberian Peninsula in the Middle Ages: The Kingdoms of Portugal, Castile-Léon, Aragon-Catalonia. (Drawing: Marcel Pujol)

divided into two naval traditions that would consolidate their implantation in each area while increasing their technological differences: in the Atlantic area, ships built by the shell-first principle and with lapstrake planking (or clinked), the use of a single mast with a big square sail as a propulsion system and a single lateral rudder on the starboard side (and from the mid-twelfth century onwards, the stern rudder), while in the Mediterranean area ships were built using the skeleton principle, with edge-to-edge planking, one or two masts with a lateen sail and a double lateral rudder.

Not only is there a great technological difference, but it also significant differences from a linguistic point of view. From the fragmentation of the Western Roman Empire and the expansion of Islam, Latin would evolve into the current Romance languages: Galician-Portuguese, Spanish, Occitan-Gascon, and French in the Atlantic; Catalan, Occitan-Provençal, Italian, Sardinian, etc. in the Mediterranean. It is obvious that the Romance languages of the Cantabrian and the Atlantic were strongly influenced by the Germanic languages, while the Romance languages of the Mediterranean were influenced by Greek-Byzantine and Arabic (and in a way Latin), which consequently also provoked a difference in naval and nautical terminology in each area.

This is the reason why the terms of the pieces that form the hull differ so much between the Latin Atlantic and Mediterranean languages. We have a clear example in the two main pieces of a frame, the central one, the floor timber, which forms the base, in Spanish called *varenga*, in French *varengue*; while in Catalan it receives the name of *madís*, *madier* in Occitan-Provençal, *matera* in Italian; and the lateral piece, or futtock, that forms the sides of the hull in Spanish is called *genol*, *genou* in French, *genoilh* in Occitan-gascon, while in Catalan it is called *estamenera*, *estamenaira* in Occitan-Provençal, and *staminale* in Italian-Ligurian (Pujol i Hamelink 2006).

From the moment that the Christian kingdoms of the north of the Iberian Peninsula began to gradually expand their domains to the south from the twelfth century (Catalonia: Tarragona 1114, Tortosa 1148; Castile and León: Toledo 1048, Calatrava 1147; Portugal: Coimbra 1064, Lisbon 1147), colonization of new territories expanded the linguistic domain of the three languages, with one big difference, Portuguese advanced along the Atlantic coast and Catalonia along the Mediterranean coast, while Castile always expanded inland. The Kingdom of Castile and Léon considerably expanded its territory but the coast where its maritime terminology was used would continue for a few centuries on the Cantabrian coast. Atlantic naval terminology was expanded naturally and progressively with Portuguese and Mediterranean naval terminology with Catalan (and also Arabic terminology).

In the middle of the thirteenth century, Portugal conquered the Algarve (1249), the Crown of Aragon conquered the Kingdom of Valencia (1245) and the Kingdom of Castile and León finally reached two seas at the south, the Atlantic by the Gulf of Cádiz (1262), and the Mediterranean by conquering Murcia (1243).

As so often happens, all is not so simple. As mentioned in Chap. 4, the Portuguese expansion does not seem to imply a substitution of the naval technology used in hitherto Muslim Portugal by the Atlantic technology used in Porto. It seems that in Portugal the Atlantic technology remained in the north coast while Mediterranean technology prevailed in the south.

In the case of Catalonia (and its expansion by the Aragon Crown) there was no coexistence of two technologies, nor the substitution of one for the other, since the (skeleton) construction principle, the propulsion system (lateen sail), and the steering system (double lateral rudder) used on the Catalan coast and on the Andalusian coast was the same.

On the other hand, the situation in the Kingdom of Castile and León is much more complex. Originally, and for many centuries, the only coast it had was in the Cantabrian Sea. In the year 1247–1248 the Castilian troops besieged the city of Seville, in which, for the first time, the process of Castilian territorial expansion to the south would receive the support of the Castilian fleet of the Cantabrian Sea. The *cocas* arrived from the Cantabrian Sea, went up the Guadalquivir, until they reached Seville, where they rammed and broke the boat bridge that crossed the river, increasing pressure on the besieged city until its capitulation. The colonization and repopulation of Andalusia—except for the Muslim kingdom of Granada, which will not be conquered until 1492—meant an arrival of people from the interior of Castile but also of people who arrived by sea from the Cantabrian Sea. The possible coexistence of two naval technologies in Seville and the Gulf of Cádiz (the Mediterranean-Arabic and the Atlantic-Castilian) remains an understudied phenomenon. On the other hand, Alfonso X the Wise created in Seville the shipyards of galleys (1254) of the kingdom of Castile, taking as reference the architectural ensemble of Mediterranean origin and the galley as a combat ship, as it was in vogue in the Mediterranean navies of the moment (Genoa, Pisa, Venice, Barcelona). The galleys were Mediterranean in terms of construction technology, rigging, and government, and so was part of their crew. The most responsible officer, the *còmit* or *cómitre*—the commander who leads the rowers—were hired among Catalans, Provençals, Genoese, and other Levantines (Pérez-Mallaina 2012).

The Kingdom of Castile and León came to the Mediterranean Sea by conquering Murcia and Cartagena (1243). This territory was lost with the Muslim revolt (1264–1266), being reconquered by James I the Conqueror—king of Aragon and father-in-law of Alfonso X the Wise king of Castile, repopulated with Catalans and ceded the territory back to Castile. Presumably, the naval technology of this coast continued with the Mediterranean naval technology, both Andalusian and by the Catalan repopulation.

This is the naval panorama of the Iberian Peninsula in the second half of the thirteenth century: the Crown of Aragon in the Mediterranean unchanged from the point of view of its technology; Portugal in the Atlantic, with Atlantic technology in the north and Mediterranean in the centre and south; and Castile and León, with Atlantic technology in the Bay of Biscay and Mediterranean in the Gulf of Cádiz and Murcia, although with the presence of seafarers and shipwrights from the Bay of Biscay and other Christian states in the Mediterranean. In a certain way we could say that there were two pure areas from a technological and terminological point of view, the Castilian Cantabrian and the Catalan Mediterranean, in the rest of the Iberian coasts there was a presence and coexistence (with varying degrees of importance) of the two naval traditions.

1.1 Information Sources and Iberian Naval Technology

The control of the Strait of Gibraltar by the Kingdom of Castile and León during the second half of the thirteenth century, along with the rest of the Iberian coasts by the Kingdom of Portugal and the Crown of Aragon, can be considered to a large extent the starting point of the Naval Revolution of the fourteenth and fifteenth centuries. The study of this process of change is carried out from various sources of information. Logically, the main one is written documentation, both archival and literary, followed by iconographic and archaeological documentation, in addition to often being supplemented by the contribution of ethnoarchaeology, modelling, and experimental archaeology.

2 The Written Documentation

During the High Middle Ages, specifically from the eleventh century, there was a change in Mediterranean geopolitics when the Muslim and Byzantine maritime domain was replaced by that of Genoa, Pisa, and Venice. In the thirteenth century the great territorial expansion took place of the Iberian Christian kingdoms and the emergence of Barcelona (and the whole of the Crown of Aragon) as a new maritime power in the Mediterranean (conquest of Majorca 1228, Sicily 1282, Malta 1282). The political and territorial, demographic, and economic expansion also led to a documentary explosion thanks to these factors, but also due to the recovery of Roman law, which led to an increase in the production of written documents and their preservation, by giving more probative value to the written document than to oral testimony in trials, to which must also be added in this century the appearance of a new medium: paper. Roman law spread from the universities of Bologna (Italy) and Montpellier (then under the Crown of Aragon) through all the Christian states of the Western Mediterranean, and later inland, towards France, Navarra, Castile, and Portugal. A good part of the institutional archives was created and consolidated from the thirteenth century, as well as a new figure associated with Roman law, the notary, and the protocol archives, in addition to the private archives, basically of merchants, and finally from the creation of the municipalities thanks to the cession of seigniorial privileges, the municipal archives were born.

All these documentary finds inform us about institutional and private shipbuilding, buying and selling of boats, the capture of ships and the sale of booty, and the hiring of crews, among the most outstanding maritime activities. The information is diverse and complex, we have the names of each naval type, the parts and elements of the structure and their rigging, their measurements, including length, and volume, in addition to the units of measurement, the price of the ships, their origin, type, and function of construction materials, the construction process, the craftsmen involved in construction and repair, etc.

But keep in mind that there is an overrepresentation of two types of ships, on the one hand the galleys built mainly by the kings and the *naus* or large trade ships used by merchants. In the medieval society these ship-owners made most use of the notary, generated more documents (correspondence, accounting, etc.) and therefore have important personal archives. In contrast, fishermen, merchants, and ship-owners who used medium and small size vessels and short distance trade, hardly passed through the notary, and consequently a documentary vacuum was produced in the case of fishing boats and smaller vessels.

Literary documentation produced between the thirteenth and fifteenth centuries is also an important source of information, highlighting works in Galician-Portuguese and Castilian in the kingdom of Portugal and Castile and León such as *Las Cantigas* and *Las Siete Partidas* by Alfonso X the Wise (López 1843; García Cuadrado 1993) and the *Victorial* (Navarro González 1962); and in the Crown of Aragon different works in Catalan, such as the compendium of maritime law *Book of the Consulate of the Sea* (Colón and Garcia 1981–1987), the four *Great Chronicles*

(Soldevila 2007, 2008, 2011, 2014), the work of Ramon Llull (1906, 1917, 1932) or the cavalry novel *Tirant lo Blanc* (Martorell and de Galba 1979). Literature usually gives much more lively information than archival, narrates what happened, using verbs and adjectives, unlike archival documentation that is much more concise and simpler, often long lists of prices, expenses, or salaries. The novels and the chronicles describe the scenes and episodes of navigation, storms, battles, rigging, rudders, oars, coasts, and ports.

3 The Iconographic Documentation

The iconographic documentation is basically religious, especially during the High Middle Ages, with naval images related to the Old Testament (Noah's Ark, Jonah, and the Whale) and the New Testament (Jesus and the apostle-fishermen Peter and Andrew). The truth is that the images of Romanesque art are usually very simple, sometimes deformed, unrealistic, and some taken from images of antiquity. From the thirteenth century onwards, the representations of ships improved considerably, much more realistic, with more constructive details, both of the hull and the rigging. Some images of a religious and also profane character decorated the palaces of the nobility or the *bourgeoisie*. In the late Middle Ages, Gothic art represented the same religious images from the previous period, to which were added those of the saints and an object that multiplied the naval iconography: the altarpieces. The perfect element that allows to represent the hagiography of each biblical and saintly personage, and therefore the scenes of miracles related to the sea (Saint Ursula, Saint Nicholas, Saint Felix, Saint Magdalen, etc.). Virtually all parish churches, monasteries, hospitals, and palaces had chapels dedicated to a saint with a maritime scene at some point in his life (Nuet Blanch 2000).

From the fifteenth century, with the arrival of the international Gothic style, the opaque and golden background of the altarpieces began to be decorated with landscapes, in which rivers and seas, therefore ports and ships, may appear, thus increasing the number of naval iconographies. The problem is that there is no relation of the saint to whom the altarpiece is dedicated with the presence of ships in the background landscape.

The vessels that are represented in the altarpieces basically correspond to two types, the fishing boat (for Saint Peter and Saint Andrew) and the *nau*—the great trading ship—in most of the other images. No minor merchant ships appear or those of medium size, nor of war, only the great merchant ship, surely because many altarpieces were financed by artisans and merchants related to maritime trade, the basis of their economic wealth.

Another object of study are the seals, in which those of the councils or municipalities of the Cantabrian Sea stand out, as well as those of the *drassaner* or arsenal manager in the Catalan-Aragonese crown, which show in the former the most important economic activity of the place—whale fishing, sea trade—and the military navy, with a shipyard and galleys in the latter.

Finally, ship models, in the form of votive offerings for the most part, are known from their presence in church inventories. It seems that, apart from religious ships, the only medieval model of an Iberian ship is the well-known model of the *Catalan nao* or *Coca de Mataró* that is kept in the Maritiem Museum in Rotterdam (van Nouhuys 1930, 1931; Winter 1956; de Meer 2004; Pujol i Hamelink 2018a).

4 The Archaeological Documentation

This category of evidence is the least abundant, although the information it offers us is capital. We have the original object, not its painted representation or written description. It is evident that after a few centuries under the sea or covered by sediment, only a part of the ship was conserved, which in this case usually corresponds to the bottom of the hull as a rule. This contrasts with the iconographic evidence. Archaeological remains most usually comprise the bottom of the ship below the waterline while the iconography shows us the ships sailing, therefore representing the hull above the waterline and the rigging. Thus, the archaeological and iconographic documentation complement each other perfectly.

5 Shipbuilding

Thus, starting from the fifth century, a technological frontier between the Mediterranean and the Atlantic was consolidated, creating two different naval spaces, evolving separately and practically without any contact until the thirteenth century. The Mediterranean naval tradition based on the skeleton construction principle, with edge-to-edge planking, the use of the lateen sail (on large merchant ships with two masts) and double lateral rudder, while in the Baltic and Atlantic the naval tradition was based on the shell-first principle, with clinkered planking, a single mast with a square sail and a single starboard rudder (and a stern rudder from the twelfth century onwards).

5.1 Mediterranean Naval Technology

As we have commented, this was present in all the Mediterranean coast of the Iberian Peninsula and also on the Atlantic side up to the north of Portugal, thanks to the expansion of Islam.

The Mediterranean is divided into two seas, the Western and the Oriental, the first being Latin, with the cities of Amalfi, Pisa, Genoa, Marseille, and Barcelona, and the second Greek-Byzantine, with Constantinople and Venice. What favoured some differences between one and the other, for example, terminological (in the

Western Mediterranean the ship carpenter is called *mestre d'aixa* while in the eastern it is the *marangone;* or the template, *gàlib* in the first and *sesti* in the second); but also of naval units of measurement, the *gua* in the Western Mediterranean and the Byzantine *pie* in the Eastern. The Muslim maritime world should not have been much different from the Christian north bank, although it is much more unknown.

Shipbuilding took place in private local shipyards and royal shipyards. The local or small shipyards were present in many coastal towns, dedicated above all to the construction of fishing boats. The shipwrights used to have their barracks and the slipway on the beach, next to the fishermen's barracks, their boats and nets, although all of them had their domicile within the town. In ports where commercial activity existed, the presence of ship carpenters could be greater and dedicated in this case to the construction and repair of commercial ships of different sizes (middle-size and cabotage ships and boats), in addition to the usual fishing boats.

On the other hand, military vessels, such as galleys and related (*galiota*, *tarida*, *sagetia*, *uixer*, *fusta*, *pàmfil*, etc.) linked to power, were built on the beach or in a royal shipyard, both in Barcelona and in al-Andalus (Torres Balbás 1946; Lirola Delgado 1993; Molina López 1995). The Catalan *drassana* or royal shipyard (from the Arabic *dār al-sinā'a,* 'construction building') was a space delimited with stakes or a wall, but open to the sea, to build and especially keep the galleys when they were inactive. With the passage of time, the shipyards became a fortified space, with warehouses for rigging, ammunition, and weapons, a building divided into spaces that would be covered with a roof and be able to keep the galleys safe from inclement weather and thus extend the life of these vessels.

The great difference between the vessels is functional (fishing, trade, war), but this function ends up conditioning the shape, the construction materials, the propulsion system, the type of crew, etc. In a merchant ship what takes precedence is their carrying capacity, which is why they are usually ships with a round appearance, with a length to width ratio of 1:4, as well as being tall, bulky, and heavy-looking. Merchant ships used sail as a propulsion system, for which they needed a small crew, and consequently they had more space for cargo, and it was not necessary to make as many stopovers during navigation. On the other hand, in military vessels such as a galley, where speed and manoeuvrability take precedence, they tended to have little draft and little freeboard, in order to minimize resistance to fluids (water and air), of very light construction, their ratio length-width was 1:8 in the *sotil* galley, the standard of combat (while the bastard galley was 1:7 and the thick galley or *galiassa* was 1:6). Two propulsion systems were used in the galleys: sailing and rowing. The first usual during routes if there was wind and the second for combat, windless navigation, and manoeuvres in port. The large number of rowers, in addition to crossbowmen, sailors, and officers, more than 100 men, required repeated stops for their refreshment. Of the three types of galleys, only the thick one or *galiassa* was also used as transport or merchant, due to its carrying capacity.

All ships and boats were built according to the same skeleton principle and with edge-to-edge planking. This is indicated by the different sources of information. But keep in mind that a shipwright did not build all kinds of boats, nor did all shipwrights build boats and ships. It is necessary to make a clarification, the typical ship carpenter that could be found in most coastal towns was dedicated to the construction and repair of fishing boats and other smaller vessels (cabotage trade and auxiliary boats of galleys and ships), had his barracks and construction material on the beach, in addition to the necessary tools, and as a builder he had his *gàlibs* (the templates that allowed to shape the stem, the sternpost, and the frames). This is the big difference with the shipwrights who were not builders, they had no barracks, few tools and had no gauges, these ship carpenters were working for other shipwrights, moved to royal shipyards when there were labour shortages, or they embarked on ships and galleys to work on their maintenance during navigation (in this case many ended up assuming a new role: *nauxer* or pilot, upon acquiring nautical knowledge, and according to *post-mortem* inventories having navigation charts and compasses). There were also differences between the shipwrights, there were those who only built smaller boats and those specialized in the construction of ships and others specialized in the construction of galleys.

The shipbuilders were only found in the most important ports and in the royal shipyards. In these, the complexity of the construction of a *nau* and a set of galleys, by the volume and weight of a ship, but also by the quantity, quality, and variety of human and material resources required a master shipwright (director), along with a group of ship carpenters and apprentices who helped him, in addition to other artisans. In a shipyard, although it seems that a galley was easier to build, as a rule not a single galley was built, but several at the same time, for which the master shipwright—who owned the templates—had to coordinate the works, building the galleys in series, in phases, in which groups of artisans passed from one galley to another under construction, so that they were not stopped and four or six galleys were built in 4 months, optimizing working rhythms as much as possible.

In all constructions the main person in charge was the master shipwright, although there was a phase of the process in which the responsibility was left to another craftsman, to the caulker responsible for the waterproofing. Normally this occurs when the hull is finished, when the last piece of the planking has been placed (in cat. *romball*) and the hull is said to be white, the caulk will turn it into a black hull. The caulker did not have a barrack, but a set of tools, such as iron and mallet, to put the thread of tow in the joints of the planking and later impregnate the entire hull with pitch. This required a cauldron to liquefy loaves of pitch and a *llanada* (a stick with wool) to apply the pitch to the hull. It was a normal operation in all coastal towns, both in construction, as well as in repairs and maintenance. Almost once a year, the hull had to be checked and caulked to avoid leaks. In the construction of ships and galleys, the amount of work required a set of caulkers to intervene, in this case under the direction of one or more master caulkers, along with caulkers and apprentices. There is also the case of caulkers that embarked on ships and galleys, where they also acquired nautical knowledge and also became *nauxers* or pilots (since navigational charts and compasses also appear in their *post-mortem* inventories).

Once the hull was black, the caulker ceded the construction to the ship carpenter again, since there were always aspects to be finished (decks, interiors, rigging, rudder, decoration, etc.), and his responsibility did not end until the ship was launched into the sea and ready to sail.

Previously we referred to a documentary typology, construction contracts, where the contractor appears, that is, the ship-owner, in cat. *Senyor de la nau* (lord of the ship). Sometimes he is a part of a society—in this case he is usually the one with the major share and at the same time can act as skipper of the ship, and the hired ship carpenter or *mestre d'aixa* (literally master of adze). The agreement between the two parties defines the type of boat, its general dimensions and the total price. Many times, the construction cost must be paid in different instalments, as the construction progressed, thus coinciding with the different stages of the construction process (framing, planking, caulking, and launching). Thus, the archive documentation indicates a series of phases, beginning with: (1) *Seure* (planting the keel on the ground or slipway). (2) *Enramar* (placing the frames). (3) *Cenyir* (adding all the interior and exterior longitudinal elements: keelson, bilge strakes, footwales, wales, etc.). (4) *Cloure* or *fer blanc* (planking the hull). (5) *Calafatar* or *fer negre* (caulking). (6) *Beneïr* and *varar* (bless and launch). (7) *Arborar* (rig) (Pujol i Hamelink 2012).

These phases clearly indicate that the construction principle is that of a skeleton, in which the shape of the hull is given by the longitudinal section given by the stem, keel, and sternpost and the cross section given by the master frame, which is completed with the rest of the frames and the longitudinal elements for reinforcing the structure, subsequently covering the entire shell with the planks. Basically, the frame is defined and built in the phases of *seure*, *enramar,* and *cenyir*, while the planking is put on *cloure*. One of the most important characteristics of this construction principle is the caulking of the hull, to waterproof it, which also indicates that the last plank was placed at the end.

In another documentary typology, the account books collect the amounts destined to all kinds of expenses, such as the salaries of the operators (ship carpenters, caulkers, sawyers, etc.), the purchase of construction material and caulking (wood, nails, bolts, pitch, tow, etc.), but also the daily or a few days in advance purchase of food and drink. This type of expense allows us to know the celebration of the beginning or end of an important phase of the construction process. For example, the extraordinary purchase of white wine and beef to celebrate that the entire hull has been planked, since lamb and pork are usually eaten and red wine drunk. The *festa del romball* is the party in which it was celebrated that the hull had been completely planked, since the *romball* is an element of the planking, it is not a table but the last piece of wood that finishes off the planking process. A party was held at the time the hull was white and the caulker had yet to intervene. Another type of expense was the purchase of golden cups by the ship-owner. In this case the cups were associated with a festive act related to the finishing, baptism, and launching of the ship. The cups were delivered by the ship-owner, or his representative, to the master shipwright and to the master caulker, and these two delivered in exchange the tools that identified them, the adze of the master shipwright and the mallet of the master caulker (Pujol i Hamelink 2018b). In addition, the episcopal license had to be paid to bless the ship and all the expenses of liturgical and festive nature of this day (musicians, priests, dishes, food, and drink).

If this documentation gives us information about the principle and the construction process used, one of its main characteristics is the determination of the shape of the main parts of the hull structure (stem, sternpost, frames). In this case we have to highlight the existence of different Venetian manuals or recipes from the fifteenth and sixteenth centuries, highlighting Mauro Bondioli (1996, 2003a, 2007a) as the main researcher, and as for the wrecks, these are limited to Culip VI, in Catalonia, from the end of the thirteenth century, studied by Eric Rieth (1998, 2005) and the review and study of the wrecks located in a Venetian context: Contarina I (Bonino 1978), the galley of San Marco in Boccalama, and the Lazise ship, from the fourteenth to sixteenth centuries, by the aforementioned Bondioli (Beltrame and Bondioli 2006; Bondioli 2007b).

Between the eleventh and the thirteenth centuries, there was a simplification of the mechanism that regulated the construction process. The shipwrights concentrated all the information required to determine the shapes of the frames in a single template: the *gàlib mestre* or master gauge. In this way they eliminated the use of different gauges and decreased the importance given to the ribbands in determining the shapes of the frames. The ribbands are the wooden rods that were nailed longitudinally to the outside of the hull to check that the set of the frames had the appropriate shape, to be unlocked later and proceed to their planking. On the other hand, the master gauge is about the template that gives shape to the master frame, or rather half master mould which, by symmetry, shapes the entire mould and in many cases also serves the two master futtocks. In addition, the various reductions that frames receive as they move away from the master frame and approach the fore and aft ends (such as plan and beam decrease, and loss of horizontality, are transported to the master mould). Obtaining these differences was done by comparing the shape of the master frame with the tailframes—frames that sat at the ends of the keel. From here, to lack an instrument that permit it was applied to the frames located between the master frame and the bow and stern tailframes. These reductions were achieved from the use of different diagrams, as the triangle and *mezza-luna* as reflected in different Venetian documents from the fifteenth century, but which should have been in common use as early as the twelfth and thirteenth centuries. The reductions of the plan were transferred to the master mould and those of the horizontality to a tablet. The use of the master mould, the tablet, and a ruler allowed shipwrights to shape virtually all of the hull frames (Fig. 6.2). These, made up of floor timber and futtocks were made on the ground, applying the three instruments on the piece of wood, marking the shape with a red tint, and drawing three lines that corresponded, the first to the axis of symmetry to (or part of the floor timber that would sit on the keel) and the other two at each end of the plan of the floor timber (marking the point of *escoa* or beginning of the bilge). The shape of the piece could be painted with the core, while the three lines could be made with a punch. The large number of frames that were being produced also required controlling the order and position that they would have when mounting them above the keel, this made it necessary, as demonstrated in the Culip VI wreck, to mark them with numbers, starting logically by the master frame with the I, and so on towards the bow and stern (II, III, IIII, V, VI …). The number marks were also made with an awl, since once the floor timbers were

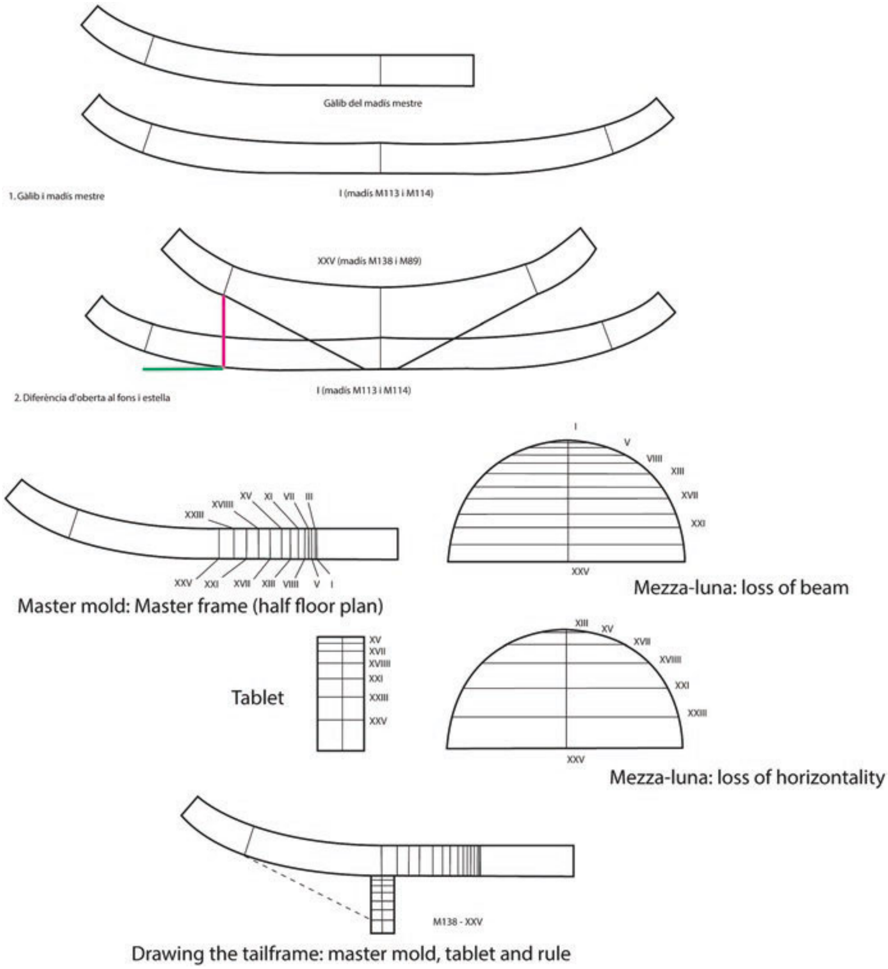


Fig. 6.2 The use of the master mould: from the master frame to the tailframe in Culip VI (1275–1300). (Drawing: Marcel Pujol)

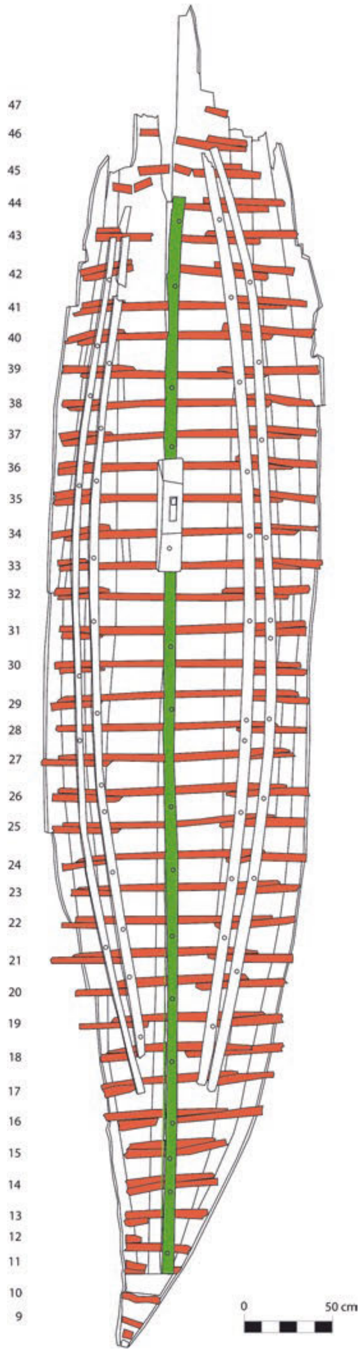
made, the construction of the entire frame was not immediate, and it could take even more days to place the entire frames on the keel. This is why what is marked with a punch mark that marked the position of the frame on the keel, the end of the plan and the number that indicated the position assigned to each frame.

The study of the construction details on the wrecks allows us to better understand how the construction process was, how the different parts of the structure were, the relationship between them, the joints or scarfs and the fastening elements, and hopefully we will find the traces of the use of elements typical of the construction process but not found in the built hull. Recall that there were a whole series of wooden pieces that did not appear in the hull of the sailing ship, but were used during the construction process, such as the slipway, the stanchions, the scaffolding and ladders, the winches to handle large heavy parts, those timbers to facilitate launching, and above all the ribbands or parts that are only used during the construction process but that can leave their presence in the hull of a ship or boat in the form of a hole of the nails that were used to fix them to the frames.

In the case of Culip VI, and it seems to be a Mediterranean norm, the floor timber and its futtocks were laterally spliced with a hook scarf and nailed with two long nails: one from the floor timber to the futtock and the other one from the futtock to the floor timber, creating the frame. Once all the frames were produced, they proceeded to mount them on the keel, stem, and sternpost. From this phase on, a whole series of pieces appear that are gaining more and more importance, give more cohesion to the structure, and at the same time allow reduction of the thickness of the frames and construction of a lighter hull. They are all longitudinal pieces, both interior and exterior. In the first place, the keelson that will fit on the posts and is fixed by means of iron or wooden bolts to the keel, as a rule through the whites to avoid damaging the posts, as they do not have enough thickness. On both sides the *escoa* or bilge strakes were placed, which could have the same thickness as the planking but they were indented and fitted to the frames, and they could also be made of another type of wood. Their main function was not the planking of the hull, but it was to keep the frames in position, to have the required separation and in a way they also acted in as a ribband. In addition, one or two footwales were placed inside, also indented and fitted to the frames, following the end of the plan of all the frames, and fixing one of the two footwales by means of iron or wooden bolts to the bilge strake, also through the space between frames. The important role previously given to the tape in the cohesion of the structure is being transferred to the different longitudinal elements, such as the bilge strakes, but also to the interiors, such as footwales, shelf clamps, and spirkettings. This fact is also noted in the Venetian area in wrecks, such as the Contarina I ship and the galley of San Marco in Boccalama, both of the fourteenth century, and naval recipes from the Arsenal of Venice of the fifteenth century (Beltrame and Bondioli 2006). Every longitudinal exterior part has its corresponding interior timber, to which it is joined by bolts (keel-keelson, bilge strake-footwale, wale-clamp). This set of parts allows greater cohesion to the whole structure and reduces the thickness of all the wooden parts of the hull, thus obtaining a more cohesive, stronger, and lighter ship or galley (Fig. 6.3).

Leaving the hull aside, a technological change is seen also at the level of the propulsion system, both of the sail and the oar. The lateen sail used at least from the second century AD was imposed on the square sail of Antiquity from the fifth and sixth century, before the expansion of Islam (Bass 1972, p. 154; Casson 1994, p. 118; Pomey 2006). The square sail is virtually absent from the Mediterranean naval iconography from the sixth century to the beginning of the fourteenth, the few images of ships with a square sail appear to be copies of images of the Ancient Rome. And in the case of rowing, the superimposition of rowers on different banks, as it was used throughout Antiquity, seems to survive in the Byzantine Empire, but that in Italian navies from the eleventh-twelfth century and are the simple one, that is, of benches all arranged on the same level, in which the galleys have two rowers per bench, each one with its oar.

Fig. 6.3 Plan of Les Sorres X wreck (1375–1400). (Drawing: Marcel Pujol)



It is curious that some of the most important and proper elements of this construction system are etymologically of Arab origin. If there are words given in the Latin languages from Mediterranean to the shipwright as *mestre d'aixa*, this one of Latin origin, that of *calafat* (caulker) is from Andalusian Arabic origin (ar. *calafata*), as well as different tools and products, such as the red tint used to mark the pieces of wood, called *almagre* (ar. *al-magra*), the moulds *or gàlibs* (ar. *qálib*) used by the shipwrights to determine shapes, or the *quitrà* (ar. *al-qatran*), pitch to waterproof.

5.2 Atlantic Naval Technology

The technological landscape of the Cantabrian Sea coast of Galicia and northern Portugal remained stable during all the High Middle Ages. The shell-first principle and with the strakes overlapped were used by ship carpenters from the Baltic, North Sea, and Atlantic coasts up to the mouth of the Douro (Mörling 1994).

In general, boats and ships are built from the main longitudinal elements (stem, keel, and sternpost). In the shell-first principle the following pieces that are placed on the hull are the strakes of the planking, one after another, without frames. The planking shapes the hull and in turn forms part of the main structure, giving solidity and turning the set of strakes of the planking into a unique structure. The way to fix the different strakes in the Atlantic naval tradition is by overlapping them and using a fixing element that crosses the two strakes at the point of overlap. This gives rise to the characteristic outward appearance of shells.

The fixing system varies, so the use of one or the other gives rise to variations in the Atlantic naval tradition. Some authors have identified subgroups, by the use of nails with round or square rivets and wool thread in the overlap, typical of Scandinavia and colonized areas (clinker-clench, iron rivets, shanks), such as Normandy (French-clench, metal bolts or nails hooked over plate rove); small stalks of wood and moss in the overlap, typical of the Baltic—although it is also located in the south-east of England—nails hooked at 90° (hooked nails), with moss on the overlap, in addition to a wooden wand and staples, typical of the English coast and Friesland—from Holland to Denmark—and finally the *adirondack*, with the iron nails that go back into the planking (180°) typical of the cog tradition (McGrail 2004).

Among the first documentation that informs us about the Atlantic naval tradition present in the Cantabrian Sea, we must highlight municipal seals. In some with *cocas* (merchant ships or cogs) with the clinker planking and a single mast with a square sail (Santander 1282, San Sebastián 1297), and in other whaling boats clinkered too (Hondarribia 1297, Biarritz 1351). The iconography does not allow us to attribute the Cantabrian naval tradition to any cited regional tradition. On the other hand, the archaeological remains of wrecks of Basque-Cantabrian origin, point us to the Scandinavian and Norman tradition, by the use of flat and square nails and rivets to fix the planking together.

The wrecks of Cantabrian origin have been found on the Basque coasts, but also in other parts of the Atlantic and the Mediterranean:

– Urbieta (Gernika, Basque Country). Small ship about 11 m in length, dedicated to the transport of iron ore, dated the hull wood by C14 in 1450–1460 (Izaguirre and Valdés 1998; Izaguirre et al. 2001; Rieth and Izaguirre 2004; Rieth 2006).
– Aber Wrac'h 1 (Brittany). Ship about 25 m long and 8 m breadth with a dating of the first half of the fifteenth century. This wreck is attributed to the ship of an English merchant named Marquiez, which sank in 1435. Although the origin of the construction of the ship is in Aquitaine or on the Cantabrian coast (L'Hour and Veyrat 1989, 1994).
– Newport (Wales). Ship of about 26 m in length preserved, probably the original total length would reach 35 m, for a beam of 8 m, with a burden of 100–200 tons. It would be a ship dedicated to trade between the Iberian Peninsula and England. Its origin is located on the Cantabrian coast, where it was built between the years 1445 and 1456, and sunk from 1468 to 1469 (Nayling and Jones 2014; Jones and Stone 2018).
– Barceloneta I (Barcelona, Catalonia). A ship of about 100 tons and a little over 20 m in length, of Cantabrian origin, of which only a fragment of the starboard side remains. Its construction date dates back to 1410, while its abandonment took place around 1430 (Soberón et al. 2012; Pujol i Hamelink et al. 2017) (Fig. 6.4).

Fig. 6.4 Remains of an Atlantic ship: Barceloneta I (ca. 1430). (Photo: Mikel Soberón)

– Cavalaire (Provence). Ship of about 70–100 tons burden, of Cantabrian origin, with a date around 1479, in fact a repair carried out surely in a Provençal port. Unlike the previous ones, in this case we are faced with a mixed type construction, with a skeleton construction principle, and edge-to-edge planking for the bottom and clinked on its sides (Delhaye et al. 1996; Loewen and Delhaye 2006).

In all of them, features of the Nordic-Scandinavian tradition are detected (Crumlin-Pedersen 2004):

1. Iron nails at the junction of the overlapped strakes from the outside to the inside (Urbieta, Aber Wrac'h 1, Barceloneta I and Newport).
2. Square rivets on iron nails, on the inside, and the tip of the nail was finished off at 90° (Urbieta, Aber Wrac'h 1, Barceloneta I and Newport).
3. The treenails to fix the frames to the planking also from the outside to the inside. All wrecks have this fixing system.

And some specifically Basque (or Cantabrian) features such as the use of:

1. Moss between strakes as waterproofing element (Aber Wrac'h 1, Barceloneta I, and Urbieta, while in Newport animal hair was used).
2. Oak wood in all the pieces of the structure (planking, frames, and treenails). All wrecks have oak in all the hull's wood pieces, with the exception of the use of beech wood for the keel (Loewen 1998).
3. A larger template for the frames and narrower gaps. Although these last two aspects would surely denote that we are in front of a larger ship, and that it must bear a more voluminous and heavier load. This characteristic also appears in the wrecks of Aber Wrac'h 1, Newport, Barceloneta I, and Cavalaire; while that in Urbieta given lower vessel type, the frames are less thick with greater spacing between frames.
4. The use of 70-year-old oaks in the framing (Dominguez-Delmás 2009). This characteristic is repeated in Cavalaire, where most of the first and second futtocks are between 60 and 70 years old. Loewen believes that the supply of wood in the Basque Country provided pieces with standard measures and shapes, facilitated by forestry practiced in oak forests. It suggests a close relationship between shipbuilding, frame design, and forest policy. The age of the oak wood used for frames is repeated in more recent wrecks of Basque origin, such as the San Juan galleon of Red Bay (Canada) sunk in 1565 (Grenier et al. 1994). The age and nature of timber employed in early modern Iberian vessels is further explored in Chap. 14.

Of all the late medieval wrecks, the Cavalaire wreck is the most atypical since it is a mixed construction, reflecting the transition that took place throughout the Atlantic area during the second half of the fifteenth century in the construction of merchant ships. If we look at its dating (1479) it is a very late date and in which the principle of skeleton construction had already been imposed on the Basque shipyards as we will see later.

6 Enclaves and Technological Aliens

Although the European coasts were divided into two naval traditions, the Atlantic and the Mediterranean, along the coasts of Europe there were what we call enclaves and technological aliens. That is, the existence of an exogenous technological island or construction site with technology and methods foreign to the geographical environment where it was located; while the technological alien would be an object, in this case a wreck, of a ship built in a geographical and technological space different from the place of discovery.

Before the fifteenth century, the construction of Mediterranean ships in the Atlantic was an exceptional event, linked to the prestige of the galleys and the echo of the naval battles that took place in the Mediterranean. For this reason, at different times, political and military reasons favoured Genoese, Provençal, Catalan, and Venetian ship carpenters to move to different ports on the Atlantic coasts. In some places, he was commissioned to build a galley, and in others, a dockyard was created, where a series of Mediterranean technicians (ship carpenters, caulkers, sawyers, sailmakers, etc.) worked, building galleys for a long period of time.

The best-known Mediterranean enclave is the *Clos des Galées* (Rieth 1989, 1990, 1996, 2002), the shipyard created in Rouen, Normandy, by King Philip the Beautiful (1284–1305) of France in 1292, after having participated and witnessed the naval battles that took place on the Catalan coasts between the Franco-papal and Catalan-Sicilian fleets in 1285. This technological enclave—a Mediterranean temporal and spatial island in an Atlantic context—was in operation for 126 years, until 1418. Although Mediterranean and Norman technicians worked in this arsenal, some built according to the Mediterranean naval tradition and the others in the Atlantic tradition. This fact becomes evident when describing the work and material used in shipbuilding. The galley *Saint Agnes* on props and practically finished, had to be *raprareillier, recourre, brusquier, calefestrer et brayer*, specifically Mediterranean terms and tasks. In return the boat *Saint Jehan* had *une neuve quille et ycelle barge recliquier, requevilleier, callefestrer, brayer* terms (especially the *recliquier* and *requevilleier*) typical of the Atlantic building tradition. We can add that the Mediterranean technicians use their own terms for the different parts of the galley's hull structure, such as *estaminairez, petis et grans madiers,* and *carenne*, while in the construction of the clinker boats the terms are Atlantic, the same pieces are called *genous*, *warengues,* and *quille*. When we say that there was a presence of Mediterranean technicians, these were mainly Genoese, but there were also Provençals and Catalans such as Jacques de la Casteloingne and Pierre Vidal. The arsenal closed in 1418, ceasing to build Mediterranean military vessels. There does not seem to be any link with the change that will take place during the second half of the fifteenth century and the beginning of the construction of merchant ships according to the principle of skeleton construction and edge-to-edge planking which in this case reaches Normandy by broadcast from the South.

In the Iberian Peninsula the only parallel can be found in the Santander galleys shipyard created by king Henry II of Castile in 1372 and which had to maintain a permanent squad of eight galleys in the Cantabrian Sea. The doubt we have is whether these were actually built according to Mediterranean practice (Casado Soto 1975).

On the other hand, we have documentary witnesses that indicate the sporadic presence of Mediterranean ship carpenters to build military vessels. The best known is the case of Padrón and Iria Flavia, in Galícia, in the first half of the twelfth century.

After visiting Rome at the beginning of the twelfth century, the Bishop of Santiago de Compostela, Diego Gelmírez, decided to create a war fleet to contain the piracy that ravaged its coasts. In 1115, he sent emissaries to different Mediterranean cities (Arles, Pisa, and Genoa) to send naval technicians to Galicia. We know that at least one ship carpenter from Genoa, named Eugerio, together with other Mediterranean people from different places (*aliosque diversarum regionis artifices (...) adhibuit*) built two galleys in Iría Flavia, in the Arousa estuary (Falque Rey 1994), which shortly after, due to the lack of maintenance, were rendered useless in the port of Padrón (Pallarés Mendez and Portela Silva 1991, p. 207). This is the reason why a third galley was built in 1120, in this case by the Pisan master Fuxon, which was used not only for the defence of the Galician coast but also to attack the Portuguese Muslim lands, where he obtained an important booty. This technological enclave lasted for less than a decade (Lixa Filgueiras 1991).

What we call technological aliens would be the Mediterranean ships and galleys present in the Atlantic. These needed to board their own technicians (ship carpenters and caulkers) not only for their maintenance due to the long and nonstop routes but also due to the lack of qualified technicians in a sea of another naval tradition. The purchase or theft of Mediterranean ships by the French and English also involved the hiring of Mediterranean technicians for their maintenance and thus avoid their loss.

On the contrary, in the Mediterranean Sea we do not know the existence of any enclave of Atlantic tradition, although we do know the presence of clinker ships, mainly merchant ships and from the fourteenth century, both in written and archaeological documentation, in this case due to the exceptional nature of two wrecks, the Barceloneta I, in Barcelona, and that of Cavalaire, in Provence, both of Cantabrian origin and dated in the fifteenth century.

The two naval traditions coexisted only in the centre and south of Portugal, the Mediterranean brought by the Andalusians and the Atlantic brought by the Christian conquerors from the north. We do not know, at the moment, the presence of shipyards where clinker boats were built in this area, but we do know of remains of wrecks belonging to this tradition. In Alfeizeráo, north of Lisbon, an isolated shed frame was found that was dated in the tenth-eleventh century (Alves 1992; Alves et al. 2005, p. 10); another similar frame in Arade B (Bettencourt et al. 2003) in the Algarve, in this case without dating; and to the south of the Douro, in Ria de Aveiro F (or 6), a mixed type construction, from the end of the fifteenth or sixteenth century (Rodrigo 2002); and in Ria de Aveiro G (or 7), an isolated frame and a set of clinker strakes from the fourteenth–fifteenth century (Alves and Ventura 2005; Alves et al. 2005, p. 12).

7 The Beginning of Maritime Traffic Between the Two Seas

In the thirteenth century, there are a number of factors that favour the establishment of a direct commercial and maritime link between the large commercial cities of the Mediterranean and the English Channel. During the preceding centuries, the commercial relationship between northern and southern Europe had been increasing, using different communication channels, both river and land, the main one being the route of the Rhone river that linked northern France with the Mediterranean. A trade route, which was also used by crusaders and pilgrims going to the Holy Land, and which in turn also stimulated naval activity and maritime trade in different Mediterranean cities (Marseille, Genoa, Pisa, Venice) to take control of the trade in exotic products found in the Near East.

Probably the most important factor was that in the mid-thirteenth century the peninsular Christian kingdoms expanded until they conquered practically the entire al-Andalus territory: Portugal conquered the Algarve (1250), the Crown of Aragon reached Murcia (1266) and Castile and León a Seville (1243), and the Strait of Gibraltar (1309). The new geopolitical situation allowed to open a new commercial route to the north of Europe, through the Strait of Gibraltar and by following the Atlantic coasts to reach the ports of *La Clusa* (Sluis), port of Bruges, in Flanders, and of *Antona* (Southampton), in England. A route safer than the unstable path of the Rhone river, especially when the Mediterranean ships allowed and carry a much greater amount of merchandise faster and cheaper way. Mediterranean cities took control of freight transport by linking eastern ports (Alexandria, Beirut, Constantinople) with Flanders and England (Verlinden 1940, p. 52; Koller 1973).

7.1 From the Mediterranean to Flanders and England, and Flemish and English Vessels into the Mediterranean?

Thus, the opening of the new maritime trade route takes place around the year 1280. On this date, the presence of Genoese, Majorcan, and Catalan ships in Flanders, and soon afterwards also Venetians is confirmed (Lane 1934, pp. 13–14; Doehard 1938, p. 60; Lewis 1976, p. 158). It is not a sporadic, specific case, but it ends up consolidating into a permanent commercial and maritime relationship. Every year merchant ships, like *naus* and trade galleys will depart from Barcelona, Majorca, Genoa, and Venice to Bruges and Southampton. In some coasts where the Flemish and English population had never seen this type of vessels rigged with lateen sail, double side rudder and hull with the edge-to-edge planking and even less of commercial galleys. A truly shocking naval landscape, spectacular and oblivious to the characteristics of the cogs or *cocas*, the great merchant ships of the Atlantic.

While the Mediterranean galleys and *naus* arrived at the ports of Bruges and Southampton, the Flemish and English cogs did not sail towards the Mediterranean. From the year 1300 we began to document the first references of Atlantic vessels regularly present in the large ports of the Western Mediterranean. And these were *biscaïnes*, understanding as *biscaí* both ships coming from Vizcaya and other Basques such as those from Guipúzcoa, and also the Castilians from Cantabria, all of them coming from the shores of the Eastern Cantabrian Sea (Ferrer i Mallol 2003, pp. 115–116; Ortega Villoslada 2008, p. 188; Pujol i Hamelink 2012, p. 121).

Not only does the archive documentation refer to this fact, but different chroniclers reaffirm it, such as Giovanni Villani, who places the year 1304 as the date of the arrival of the Bayonne *cocas* and the subsequent technological transformation of the Mediterranean *naus*:

> *In questo medesimo tempo certi di Baiona in Guascogna with parrot navi, le quali si chiamavano cocche Baonesi, passaro per lo stretto di Sibilia, et vennero in quest nostro mare corsegiando, et fecero danno assai, et dall'hora inanzi i Genovesi e Vinitiani e Catalani, used by the navicare with the car, and perchè sono di meno spresa; and this was in our nastre marine grande mutatione di navilio* (Villani 1727, p. 10).

Despite what Villani claims, there is a documentary presence of Atlantic cogs in the Mediterranean that could date back to 1280 and even beyond, although it is not significant. For this reason, Hutchinson (1998, p. 188) believes that the period between 1300 and 1310 is not the time for cog to enter the Mediterranean, but rather the time when they were imposed. And personally, it could be added that, consequently, the Mediterranean *naus* began to modify themselves (rigging and rudder) to become *cocas* or *bayonese naus* in the 1320–1330s.

There are those who can emphasize that previously Atlantic vessels had already entered the Mediterranean, but it must be clarified that they were sporadic events, in the course of military expeditions—the Crusades—or even piracy—Vikings—in no case with the intention of creating a maritime trade route between the two seas. In the different crusades, the embarkation ports of the troops arriving from all over Europe were mostly: Genoa (First 1092–1095, Third 1189–1192, Eighth and Ninth 1270–1272), Venice (First, Second 1145–1149, Fourth 1202–1204), Marseille (Third, Seventh 1248–1254, Eighth and Ninth), Brindisi (Second, Sixth, 1228–1244), and Aigües-Mortes (Seventh, Eighth and Ninth). In the Second, a fleet of 13,000 English, Flemish, Scottish, Norman, Frisian, and German soldiers arrived in Portugal, where they helped the Portuguese army of 7000 men to conquer Lisbon. In this, a minority will continue their journey to the Holy Land.

The reason that the Atlantic sailors are Basque and Cantabrian from 1300 is a consequence of the territorial expansion of the Kingdom of Castile and León to the south, to the Gulf of Cádiz and Cartagena during the second half of the thirteenth century. The Cantabrian navy was the one used to take control of these coasts. Therefore, Basque navigators who have been used for centuries to trade in the entire maritime space between Galícia and the English Channel (transporting Castilian wool and Basque iron to England and Flanders), now embark on a new route to the Mediterranean, until reach the large Latin ports (Catalan, Provençal and Italian), using Seville and Cartagena as ports of call, and acting in the Mediterranean both as a carrier and privateers.

If the demonym *biscaï* is always added to the shipmasters and sailors from the Cantabrian Sea, their ships are called *cocas* (from the Germanic *kogge*), used to refer to the great merchant ships of the Atlantic. Therefore, a word that had the same meaning as the Mediterranean of *nau* (from Latin *navis*). The truth is that from the first quarter of the fourteenth century the term *nau* and *coca* will be used interchangeably to refer to a merchant ship, it often appears in the Latin documentation as *navis sive coca* (Dufourcq 1966, pp. 40–42, 1975, p. 75). Not because of its function (trade), but because of its technology, there was a difference between Mediterranean and Atlantic *nau* and *coca*. To these last ones he will add the epithet of *baionesa* or *bayonesca*. A word that indicates a geographical origin, the port of Bayonne (today in the French Basque Country), and which also indicates that they were technologically Atlantic ships (with a clinker planking, a single mast with a square sail and stern rudder).

8 The Late Medieval Naval Revolution (Fourteenth and Fifteenth Centuries)

8.1 The Naval Revolution in the Mediterranean (Fourteenth Century)

From a technological point of view, the Mediterranean remained stable throughout the High Middle Ages. The main characteristics of the construction (skeleton principle and edge-to-edge planking), propulsion (lateen sail) and steerage (double lateral rudder) are part of the naval panorama from the sixth to the fourteenth century. It is evident that different conditioning factors can cause changes or accelerate evolution in one direction or another. In fact, the most significant change will yield in the propulsion system rowing, the system of overlapping banks used by the Navy in Antiquity is abandoned, and that lived in the early centuries of the Byzantine navy, by the creation of the vogue of two orders of rowers per bank in the galleys from the eleventh or twelfth century. Benches that are placed biased about the axis of symmetry to facilitate vogue both oarsmen in each rowing with its own oar. The reason they gave this change is yet to be resolved.

In the galleys armed with two orders of rowers, the most expert sat next to the *cossia* (the longitudinal axis corridor), calling himself this rower in cat. *planer* (because he was sitting on top of the plan, in it. *pianer;* although he was also called *vaiaavant* or *vogavant)*, while the second was named in cat. *postisser* (for sitting next to the apostis or *postissa*, in it. *postizzio*) (Fig. 6.5). Thus, the standard combat galley, known as the subtle galley, had a total of 26–30 banks per side, giving a minimum total of 104 rowers. In the galley, as a military ship, speed and manoeuvrability prevailed, making it an enormously light vessel, with little draft and little resistance to fluids, in which the breadth length ratio was 1/8, resulting in a long and thin hull that approached 40 m in length. A hull to which was added the vogue

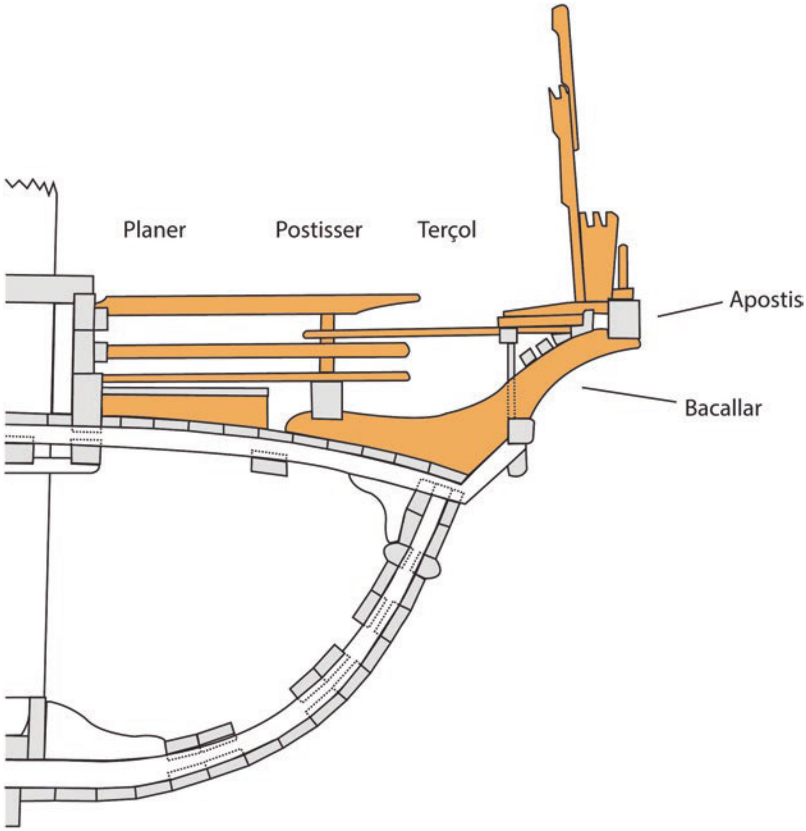


Fig. 6.5 Cross section of a galley: rowers (planer, postisser, and terçol). (Drawing: Marcel Pujol)

chamber, a rectangle formed by four pieces, two transverse to the bow and stern (the yokes) and two longitudinal ones, to each band (the *apostis*) and inside the oar banks to each band and separated by the corridor.

In rowing propulsion, to give more efficiency and less effort to the rower, an attempt is made to minimize the angle that the rowing makes with respect to the water, so that the banks are as close as possible to the waterline. If you cannot lose more, the angle is reduced giving more length to the oars, until they reach an angle of 19–21° (Pryor 1995). In an oar, the point of attachment to the gunboard, by means of the pin, divides its length in two, 1/3 part of the oar remains inside and 2/3 outside. To help the rower and reduce the effort due to the difference in weight of the two halves, it had to be compensated by placing the oars on the inside, a piece of heavy and resistant wood, called *galaverna*, and if there was still weight missing, lead was added.

The evolution in the military navy took a new leap at the end of the thirteenth century, of which, in this case, we have abundant documentary references. In the context of the conflict that took place in the seas of Sicily and Catalonia against the French and Angevins (1282–1285), armed galleys were used for the first time at *tersol*—Latin *tercilerii*, it.gen. *Terzarolo*, it.ven. *Terzicchio*, cat. *Terçol* (Sanuto detto Torsello 1611; Lopez 1932; Garcia i Sanz and Coll i Julià 1994; Pryor 1995; Bondioli 2003b). This meant the incorporation of a third rower, who will sit between the *postisser* and the *apostis*, increasing the number of rowers to a minimum of 156 and the same number of oars. It has been proved that, neither the length nor the beam of the hull were increased, but it can be said that the camera vogue was the one which was extended slightly to accommodate a new order of rowers, modifying the *bacallar*, part of support of the *apostis* and therefore from the vogue camera to the hull. These changes are reflected in the Catalan and Provençal documentation (1282–1285), Genoese (by Admiral Benedetto Zacaria in 1290) and Venetian (shortly after 1290 according to Marino Sanudo Torsello).

Because of these changes, from 1300 the standard war galley (*galea sotil*) went from a minimum of 100–150 oarsmen while the twelfth century galley of 100 oarsmen continued to exist but was thereafter called a light galley or *galiota*.

The evolution given in the rowing propulsion system not only had a military impact, but also a commercial one. The thick galleys (or *galea grossa* or *galiassa*) used for the transport of goods thanks to their load capacity (they were the widest of the galleys with a length-to-breadth ratio of 1/6) were also armed with *tersol*.

The true naval revolution took place in the second quarter of the fourteenth century due to the transfer of Atlantic technology to the Mediterranean. If the presence of Biscayan navigators was usual in the Mediterranean from 1300, it is not until the decade of the 1320 to 1330 that we can begin to detect the transformation of the large Mediterranean trade ships (Fig. 6.6). Both the iconography and the written

Fig. 6.6 *Nau* or Mediterranean trading ship of the thirteenth century. Church of Sant Miquel, Montblanc. (Photo: Gener Alcántara)

Fig. 6.7 *Nau baionesa* from the Mediterranean. Altarpiece of Saint Nicholas, Saint Anthony and Saint Clare (1375), Cathedral of Palma de Mallorca. (Photo: Marcel Pujol)

documentation inform us about the change suffered by the Mediterranean ships, at the level of the sail propulsion system and the direction, with the suppression of one of the two masts, the change of the lateen sail for the square sail and the adoption of the stern rudder. But it must be considered that there are different evolutionary lines according to the naval types. The transformation was much faster in the great merchant ships, while the merchant vessels of medium and smaller size, fishing vessels, and galleys followed other courses, in some cases only the stern rudder was introduced but not the square sail.

We do not know if the Atlantic technology influenced the Mediterranean in the Flemish and English ports or if it was the Biscayan ships in the Mediterranean ports that caused this change. And the reason is also not very clear, as there must also be a series of conditions that affect the cost of the construction and maintenance of the rigging—one mast instead of two—a sail that is extended below with the *boneta* sail and it is not necessary to carry three sails of different dimensions, less complexity of handling the square sail, ideal for carrying wind, lower cost of the single or stern rudder instead of the double lateral rudder—the reduction in the number of sailors—lower cost of wages, less space for the crew and his provisions, more space for cargo. They are especially ship-owners and traders primarily interested in applying all this technology (square rig and stern rudder) to their ships (Fig. 6.7).

During the first quarter of the fourteenth century, an Atlantic merchant ship from the Mediterranean was not distinguished between *coca* and *nau*, since the documentation places them as synonyms, used interchangeably. It is true that the term *coca* was an Atlantic and Germanic term, but it is quickly adopted by the Mediterranean navy. Documentary it is differentiated by origin when to a *nau* or *coca* the epithet *baionesca* (bayoness) is added—of Bayonne, in the Basque Country—in this case it is an Atlantic ship. In the 1320s, when the Mediterranean ships began to transform, we find *cocas* and *naus baioneses* of Mediterranean construction (Eberenz 1975).

The use of the stern rudder and the square sail in the Mediterranean ships forces to create a term that differentiates the rudder and the Atlantic sail from the Mediterranean. This will be the term *Latin,* meaning Mediterranean. As in the Catalan documentation from the fourteenth century, *timons llatins* (lateen rudders) and *vela llatina* (lateen sail), but there are also other words that distinguish one another. The stern rudder appears as *timó de roda*—for being fixed to the stern, Baioness rudder (*baionesc)*, Navarrese rudder *(navaresca)*—relative to the geographical origin, a large part of the Basque coasts had formed part of the kingdom of Navarra. On the other hand, the double lateral rudder appears as *timons*—always in the plural, as it is double—and *timons de caixa,* because they were inside a case (Casanovas 1993; Pujol i Hamelink 2012).

Practically the same thing happens in the rigging to differentiate the Atlantic square sail from the Mediterranean triangular sail, the latter is called lateen. The reality is that each mast has its own name, galleys usually ship three lateen sails of different sizes (cat. *Borda*, *tercerol,* and *artimó*), while *naus baioneses* rigged a square sail called *treu*, which is not changed by the wind, but it can be expanded at the bottom by adding more sail surface, with the *boneta*.

From the moment that practically all the ships and cogs had become *baioneses*, an attribute had to be found that would differentiate the truly Atlantic from the Mediterranean. The only or main visible physical difference was the planking, clinked on those ships that came from the Cantabrian. In the Catalan documentation we detect from 1330 the presence of *naus tinclades* and *coques tinclades*.

The Catalan term *tinclada*—and Latin *tinclata*—is a metathesis of the participle *clincata*, which in turn comes from the Germanic word *clenker* (English *clinker*, French *clin*), used by the different navies and Atlantic languages between the Baltic and northern Portugal. In the documentation written in Latin in Bayonne and Bordeaux, the term *clincata* appears, as the ship or the boat that has the strakes overlapped, and the *clincator*, or *clencator*, as the specialist in putting the rivets that join the strakes—in England called *clencher*, *clincher or clyncker*, who along with the *holders* were the specialists in putting the *clench-nails* (Bernard 1979, pp. 153, 160; Friel 1995, p. 54; Goyhenetche 1998, p. 152; Hutchinson 1998, p. 188).

Thus, everything seems to indicate that Basque and Castilian sailors from the Cantabrian Sea were the ones who introduced the word *clincata* in the Catalan linguistic area—since at the moment this word does not appear in the Provençal or Italian archives. For some reason the metathesis of *clincata* to *tinclata* occurred, and over time the conversion of /c/ to /g/ and /t/ to /d/ (from *tinclata* to *tinglada*), probably in the Cantabrian area, since in Spanish the word *tinglado* and *tingladillo* are used.

The only Italian reference that incorporates this word is found in the work of Benedetto Cotrugli, which sailed Catalan galleys owned by King Alfonso the Magnanimous at the beginning of the fifteenth century. The author talks about a *barcie* (in cat. *barxa)*, a typically Cantabrian ship, equivalent to a *nau* or *coca*, that had a clinked planking, which for this reason could not be caulked well and continuously towards water:

> *barcie sonno certa nave quadre che se usano in Castiglia, et hanno lo tavolame tavula sopra tavula, o vero madiere sopra madiere. Biscaini usano queste nave et sonno ogi in grande quantità et queste nave fanno multa acqua perché non se poçono mai tanto calcare li comenti che stiano stagne al dovere, et tucte sonno facte a talglio de baloneri (…) et non ponno sufferire multa stiva, ne anche durano molto per la loro debilitate et portano allo continuo le trombe per sgotare l'acqua la qual al continuo fanno nella sentina* (Falchetta 2009, Cotrugli, cap. XI).

The Catalan documentation throughout the fourteenth century uses the term *nau tinclada* or *nau castellana* as synonyms, therefore this ship was not really Castilian but rather Cantabrian. This term, that of *tinclada*, and also that of *baionesa*, disappeared from the documentation around 1430. As of this moment, all the great merchant ships are called *naus*, except those that come from the Cantabrian Sea which are still called *naus castellanes* (not for its technology but for its origin, although the ships from Galícia or Andalusia, which were also part of the kingdom of Castile and León are excluded). It is probable that Basque *naus* still arrive clinked long with others with an edge-to-edge planling, but all of them during the second half of the fifteenth century were called *naus castellanes*.

9 Of *naus* and *carracas*

The term *nau* (*nao* or *nave* in Spanish) is used as a generic name for all large merchant vessels (*lleny* for medium-sized vessels and *barca* or boat for minors), in the same way that the galley can be used as a generic grouping of all rowing and sail-powered vessels, be they military or commercial.

On the other hand, *nau* it is also used as a specific term, it gives its name to the largest merchant ship. This is the case in the thirteenth century, as a lateen sail-powered ship with two masts and the double lateral rudder as a steering system. From 1300–1310 the term *nau* and *coca* began to be used interchangeably, while those that come from the Cantabrian are called *coca baionesa* or *nau baionesa*. During the second half of the fourteenth century the term *nau* practically disappeared and only the term *coca* or *coca baionesa* is used (*coca tinclada* or *coca castellana* for those from the Cantabrian). At the end of the fourteenth century the rig increased, when mounting mizzen mast with lateen sail and during the first half of the fifteenth century it continued to increase by putting a third mast, the foremast, with a square sail. The increase in rigging seems to coincide with the recovery of the term *nau* and the disappearance of the word *coca*, which no longer appears in Catalan, Sicilian, and Genoese documentation after 1420 (Hocquet 1979, p. 105; Bresc 1980; Ciciliot 1998, p. 192; Pujol i Hamelink 2012).

The increase in the size and volume of the Mediterranean ships led to a differentiation between cat. *nau* and *nau grossa* (the big ship, in it. *nave* and *nave tonda*), while in Castile they are called *nao* and *carraca*. The difference between one and the other is that the carracks always have three decks and a carrying capacity of more than 1000 *botes* (approx. 500 tons).

The Castilian term *carraca* will spread among Atlantic languages: *carraque* in French, *carrack* in English, *kraek* in German and Dutch. It seems that the term spread from Castile to France between the thirteenth and fourteenth centuries, reaching England at the end of this century (van der Merwe 1983, p. 125). There are some linguists who defend this word as of Mediterranean origin, specifically Genovese, but nowadays most linguists believe it is Mediterranean, but its origin is in the Arab-Andalusian.

Corominas and Pascual (1980, p. 2) argue that proceeds from the Arab *qaraquir*, plural of *qurqüra*, or merchant ship of great bearing, that in Arabic Andalusian dialect was *qarráq(a)*, a maritime transport of great capacity. This word could have been introduced into Spanish during the conquest of al-Andalus and its repopulation with people from the interior of Castile and the Cantabrian–and surely into Portuguese from the Algarve-, where the presence of Genoese and Catalan *naus* was common during the fourteenth and fifteenth centuries (Pezzi 1989, pp. 107, 602; Corriente 2008). Everything indicates that during the first half of the fourteenth century what in the Mediterranean is called *coca* or *coca baionesa* (by Catalans, Provençals, and Italians) in Castile is called *carraca*. In a lawsuit that had to bind in Cartagena in the year 1320, witnesses who testify about a ship use one term or another according to its geographical origin: *coca* for Catalans and Italians, *carraca* for Basques and Cantabrians (Ortega Villoslada 2008, p. 432). The term *carraca* will end up being used to give name to the great ships coming from the Mediterranean.

9.1 The Atlantic Naval Revolution (Fifteenth Century)

Although the presence of Mediterranean ships was a regular occurrence on the Flemish and English coasts from 1280, and that the transfer of Atlantic naval technology to the Mediterranean occurred from 1330, the spread of Mediterranean naval technology to the Atlantic was produces much later, from 1400.

It will not be until the end of the fourteenth century or the beginning of the fifteenth century when the skeleton construction principle with the planking edge-to-edge begins its expansion from Porto to the Galician coasts, and from here through the Cantabrian Sea to the Basque Country, where it seems that it imposes in the construction of the great merchant ships from 1430.

In fact, the prelude to what was being produced in the Bay of Biscay in the early fifteenth century, we find in the purchase or theft of large Mediterranean ships to be used as merchants or warships. The *naus* and *carracas* were not only ideal for long-distance trade, for the transport of heavy, bulky, and low-priced goods, but also had a military purpose, such as a great castle in the middle of the sea, with a large presence of archers, crossbowmen, and fire artillery. In addition we can add a symbolic value, since it was the largest existing ship it had to be the king, to show its power at sea, just as it did to the castle or the palace on land.

In 1409, English pirates captured the Genoese two-mast carrack *Santa Maria and Santa Brígida*, which once in the hands of the king would be known from 1410 as *Le Carake* (Friel 1994, p. 80). In 1416–1417 England captured six Genoese carracks that had been chartered by the French. The capture or acquisition of Mediterranean vessels will make it necessary to equip themselves with Mediterranean technicians, so in the year 1420 Venetians were hired in England, which in turn brought Portuguese and Catalans: *carpenters and caulkers of foreign country… for in this country we shall find few people who know how to renew and amend the same carracks* (Friel 1983, 1995, p. 173).

And we not only know of the presence and use of Mediterranean ships by the term *carraca* but also by that of *carvel* (as an edge-to-edge planking). If during the fourteenth century in the Mediterranean, the epithet *baionesca* and *tinglada* were added for differences typical of the Atlantic, the same will be done in the Atlantic for differences typical of the Mediterranean, adding to these the term *carvel* (*carvelle* in French, *carvel* in English, *karveel* in Dutch and *karvel* in German), to indicate that it was a ship or a boat built frame-first with edge-to-edge planking. No native epithet was added to the native clinkered ships and boats because they were the usual and norm in this Atlantic context.

The use of these large Mediterranean merchant ships in France and England in the first half of the fifteenth century announces what was already taking place in the Cantabrian Sea. The diffusion of Mediterranean naval technology and its use in the Atlantic shipyards in the construction of merchant ships and warships, while medium and small vessels will continue to be built according to the Atlantic-Baltic tradition.

Friel (1995, pp. 170–180) proposes a series of advantages that the Mediterranean construction system had over the Atlantic, both economic and technical:

- It allows to build bigger ships, with a less rigid hull, slightly more flexible but using equal or less effort in its construction, and above all less wood expense.
- In the big clinker ships to shed a thicker planking was needed, which caused more tension and more effort to the nails, which in turn had to be longer and with a larger diameter. In skeleton construction and edge-to-edge planking less nails are used, they are thinner and not so long, because the planking is not thick. It also affected the fact that the logs were sawn, take advantage of lower quality wood and reduce the cost of the planking.

– It allows to design new shapes of hulls, in addition the conception of shapes from the master frame allows better control of the shape of the ship and the entire construction process.
– The number of technical specialists in construction is reduced. It is not necessary for the operators to be great masters, only one, the master shipwright, the one who defines the shape of the ship and each of its pieces, is who draws the shape of the pieces on the logs, while the rest of the operators only have to saw or work with the adze, place, and nail.
– A ship can be built in less time, therefore time is saved and less money is spent.
– The distinction is created between the shipwright and the rest of unskilled workers. Therefore, one that earns more than the rest, as they are not considered specialized, begin to earn less. In the clinker construction of merchant ships, a large amount of specialized labour was needed.

Undoubtedly Benedetto Petrogli (Falchetta 2009), in his work De Navigatione (1464–1465), is the one who can better explain the reason for changing the shipbuilding principle in the Atlantic when talking about the construction of large merchant ships. The Biscayan ships, such as the *barxa*, had the planking clinkered and for this reason water continuously entered through the overlapping of the strakes, and that if they were overloaded, more water still entered because the hull was deformed and the overlap opened more. This fact forced to empty the bilge water continuously with the pump.

For both could add even more advantages, such as ease of repair, and sealing, the possibility of portholes opening in the planking for the guns, and probably the best resistance to the weight and the backspin of artillery to the fire on skeleton-built ships.

Friel (1995) considers that it will not be the large ships that will facilitate the change and mastery of the new constructive principle by the Atlantic ship carpenters, but the medium size vessels, such as the caravel.

A slow and gradual process that will advance towards the north, until reaching the Baltic. Between 1430 and 1440 it would have been consolidated in the Basque Country—from this date Basque ships continue to arrive in Catalonia, but the word *tinclada* is no longer added to them.

In the area of the English Channel, the construction of big trade ships *à carvelle* are documented around the year 1440 (Friel 1995, p. 178). In Flanders timidly begins, in Sluis in 1438–1440, also near Brussels two ships *à karveel* were built in 1439, by Portuguese ship carpenters, for Philip, Duke of Burgundy and Count of Flanders (Unger 1973, p. 400, 1978, p. 189; Paviot and Rieth 1988). And along the coast to the north, the first ship built at the Mediterranean tradition in Zeeland and Holland it was by a Briton shipwright, called Julien, in Zierikzee and another in Hoorn, both in 1460 (Unger 1973, p. 400).

In England, carvel technology arrived and was imposed in the shipyards in the 1460s. The first known reference to a skeleton-built ship is in Dunwich between 1463 and 1466, generalizing soon after. In 1487, King Henry VII ordered the 1000 ton *Regent* to be built according to the *novel construction*, having been impressed by the carvel-constructed *Columbe*, the great French royal ship. The construction of the *Regent* used nails called *carvell nayle*, while that in small boats, such as the *Sweepstake* and the *Mary Fortune*, *soff, and clynche nayles* were employed. During the reign of Charles VII most of the ships that were built or repaired were already *carvel built*, considering themselves the complete '*carvel revolution*' between the years 1500 and 1510.

In the Baltic Sea the arrival of the Mediterranean technology took place during the first half of the sixteenth century. It is significant what the English think about the German ships that arrived at the Thames in the year 1545. They were large clinker ships to which the English admiral ironically described them as *clenchers, both feeble, olde, and out of fashion*. It says it loud and clear: the clinker ships were weak, old, and old-fashioned (Friel 1995, pp. 164, 173–174, 180).

The result is that the principle of skeleton building and edge-to-edge planking is imposed in the construction of large merchant ships, while in the medium-sized, and above all minor (auxiliary, fishing, cabotage) shipbuilding, the previous hull construction was maintained as clinker, in practically the entire Atlantic to this day. Although the Mediterranean naval tradition prevails and extends, a certain heterogeneity is appreciated because of the existing substrate in each geographical area. Presumably, the characteristic Ibero-Atlantic shipbuilding of the sixteenth century had its origin in part thanks to the changes produced throughout the fifteenth century. We must also assume that even this was not uniform, probably new lines of research (from written documentation and archaeology) allow us to observe construction details that differentiate Ibero-Atlantic construction in a minimum of three subgroups: the centre of Portugal, northern Portugal-Galícia and Cantabrian-Basque Country. A hypothesis that takes into account the differentiated reality of the naval tradition existing in each area prior to the fifteenth century and to which we must add the existence of a rupture zone, with a documented absence of shipbuilding, in Asturias, a fact that accentuates the division of the Galician-Portuguese area from the Cantabrian-Basque coast.

Small vessels were still built in the sixteenth century on the Cantabrian coast using the clinker method. Casado Soto (1998, p. 175) stated that in 1522, in San Vicente de la Barquera (Cantabria), big trading ships (*naos calafetadizas*) were built using the skeleton principle and various types of medium and minor vessels, known as *pinazas tingladas*, were built using the clinker method. In the middle of the sixteenth century, the big trading ships used by the Basque whalers in Newfoundland to carry the whale oil from America to Europe were built using the skeleton principle (Grenier et al. 1994). However, the boats used to hunt whales were clinker built. The clinker method is still used on the Cantabrian, Galician, and northern Portugal coast to build minor vessels, such as *dornas* and *rabelos* (Mörling 1994).

Acknowledgments The work forms part of the research projects: "Tripulaciones, Armamentos, construcción naval y navegación en el Mediterráneo medieval" HAR2013-48433-C2-1-P (Ministry of Economy and Competitiveness) and "La Corona Catalana, Islam y el mundo Mediterráneao" CAIMM-2014-SGR1559 (Departament d'Economia i Coneixement, Generalitat de Catalunya), both directed by Dra. Roser Salicrú (Institut d'Història Medieval-CSIC, Barcelona).

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Chapter 7
An Insight into Mediterranean Naval Architecture in the Sixteenth Century Through the Texts of Nicolò Sagri (1538–1571). A Comparative Perspective with Ibero-Atlantic Shipbuilding

Arnaud Cazenave de la Roche, Fabrizio Ciacchella, and Cayetano Hormaechea

In 1997, the existence of a manuscript dealing with Mediterranean navigation and shipbuilding in the sixteenth century was revealed in the USA at an auction organised by Christie. Four years later, in 2001, the contents of this document entitled '*Il Carteggiatore*' (The Cartographer) by Nicolò Sagri (1538–1571) were made available to researchers after being donated to the James Ford Bell Library of the University of Minnesota (Dell'Osa 2010)[1]. Although lost for a long time, its existence was known due to its evocation by Bartolomeo Crescentio in *Della Nautica Mediterranea* (Crescentio 1602). Aware of the high interest of this manuscript, the French naval historiographer Auguste Jal had searched for it in Italy, in vain,

[1] Sagri, Nicolò, 1571, 'Il Carteggiatore', University of Minnesota, TC Wilson Library manuscript n°31951SA0111372C. Online access: https://umedia.lib.umn.edu/item/p16022coll185:1222?q=sagri.

The present study is the result of collaboration between its three authors within the framework of the 'ModernShip Project'. This project has received funding from the European Union's Horizon 2020 research and innovation programme, Grant Agreement no 843337 (Marie Sklodowska Curie Actions). The translation of Sagri's manuscript on which this study relies was carried out by F. Ciacchella.

A. Cazenave de la Roche (✉)
Instituto de Historia, Consejo Superior de Investigaciones Científicas (CSIC), Madrid, Spain
e-mail: arnaud.cazenave@cchs.csic.es

F. Ciacchella
Laboratorio di Storia Marittima e Navale (NavLab), University of Genova, Genova, Italy

C. Hormaechea
Asociacio d'Amics del Museo Maritim de Barcelona (AAMMB), Barcelona, Spain

A. Crespo Solana et al. (eds.), *Heritage and the Sea*,
https://doi.org/10.1007/978-3-030-86460-6_7

between 1834 and 1835 (Jal 1840, p. 25). Its recent reappearance is a boon for research into the maritime history and Mediterranean shipbuilding of the modern period.[2]

Dated 1570, the manuscript contains 107 folios written in Italian. Its author is Nikola Sagroević, a naval officer from Ragusa (today Dubrovnik) whose duty of the training of ship's officers has motivated the writing of this treatise. The text is rich and of great value for the knowledge of the Ragusan Navy of the time, of which it reveals many aspects: life on board, role of the captain and officers, financial aspects related to the remuneration of seamen and officers, etc. It also deals with cosmography and astronomy, maritime routes and cartography, bearing in mind that it was originally intended for the training of the *Carteggiatore*, the officer in charge of navigation and maps on board. These aspects of the manuscript gave rise to a study and transcription published by Dario Dell'Osa (2010). Then a second transcription and translation into Croatian has been published (Bondioli et al. 2020).

For researchers, *Il Carteggiatore* is an invaluable new document that offers a brief but accurate overview of Italian-influenced shipbuilding of the early modern period through the example of a typical merchant ship of that time, a *nave*, the method of calculating its tonnage, the making of sails and anchors. This information is of great importance taking in account that shipbuilding in the Mediterranean nautical space of that period is still largely unknown due to the paucity of archaeological and written documentation available: To date, the studies of Mediterranean naval architecture of the sixteenth century from archaeological sources come mainly from three shipwrecks located in France: the *Lomellina*, Villefranche-sur-mer (Guérout et al. 1989), the Calvi I wreck (Villié 1989, 1990, 1991), and the Mortella III wreck (Cazenave de la Roche 2020).

Concerning the texts from the Renaissance, they are mainly Venetian and mostly devoted to rowing ships. They are the first known writings to deal with shipbuilding and are surprisingly early. The first Venetian texts appeared at the end of the fourteenth century with the 'Libro de navegar' (Bondioli 2017), and in the fifteenth century with three major manuscripts: the 'Libro' by Michele da Rodi (Long and Mc Gee 2009), the 'Libro di apunti' c.1444, by Zorzi 'Trombetta' da Modon (Anderson 1925), the 'Ragioni Antique' (Chiggiato 1987).[3] If we except those that only focus on ships of galleys family, there are few writings dealing with *navi* in the sixteenth century: we should mention the '*Instructione sul modo di fabricare galere*'

[2] The only known ragusan treatise on navigation and shipbuilding before Nicolò Sagri is that of Benedetto Cotrugli (Benedikt Kotruljević) dated to the middle of the fifteenth century (1464). Discovered in the 1990s, this text is kept in the Yale University Library. It was translated by D. Salopek in 2005, then studied and transcribed by P. Falchetta (Falchetta 2009, 2013).

[3] 'Libro de navegar', (Civic Library Angelo Mai MA334, Bergamo, Italy. Accession Number: ex Σ. VII. 29. Italy); manuscripts '*Libro*' by Michele da Rodi (private collection); the '*Libro di apunti*' c.1444, by Zorzi 'Trombetta' da Modon British Library (BL), Cotton ms. Titus A XXVI; the '*Ragioni Antique*', National Maritime Museum Library (NMML), Greenwich, ref. Cid. NVT.19.

by Theodoro de Nicolò, which contains 43 folios[4] and the '*Misure de navilii*' (1567) of about ten folios and recently published (Nicolardi 2014). We should also mention Genoese and Ragusan notarial contracts published, among others, by Gatti (1975, 1999) or Borghesi and Calegari (1970). To this narrow textual *corpus*, we should finally add the later work of the Roman Bartolomeo Crescentio, published at the beginning of the seventeenth century (Crescentio 1602), which evokes the work of Sagri, parts of which he resumed.

In this context of documentary poverty, and considering the key role played by Mediterranean technical culture in the European shipbuilding layout of the early modern period, Nicolò Sagri's treatise makes a very useful contribution to enriching our knowledge and meagre *corpus* of texts available for its study (Table 7.1). This is the reason for writing this chapter, which is divided into three parts: The first is a study of the architecture of a *nave* of *30 piè*[5] *de larghecza* that Sagri provides in Chap. 6 of his treatise. On the one hand, it aims to reconstruct her shapes and dimensions and, on the other hand, to place her typology in the context of Mediterranean shipbuilding of the time.[6] The second part aims to parallel the architectural profile of Sagri's *nave*, as shown in his Chap. 6, with the architecture of Iberian merchant ships of the same period revealed by Spanish and Portuguese authors and archaeology.[7] Finally, the last part is an analysis of Chap. 7 of the *Carteggiatore* devoted to the calculation of the tonnage of the *nave*. It aims to explain the method recommended by Sagri and to put it into perspective with the different calculation systems in use at that time, especially in the Iberian world.[8]

1 *Il Carteggiatore*'s Contribution to the Knowledge of Naval Architecture of Ragusan/Italian Influence. Study of the Dimensions, the Proportions, and Reconstruction of Sagri's *Nave*

Entitled '*Delle tre principalli missure della nave*' ('Of the three main measurements of the *nave*'), Chap. 6 of the *Carteggiatore* contains the essential information concerning the architecture of the *nave*. It is composed of only four folios written on both sides, from f°13R to f°16 V, a total of just over 1000 words. Despite its brevity,

[4] 'Instructione sul modo di fabricare galere o Arte de far vasseli' by Theodoro de Nicolò, 1550. Biblioteca Nazionale Marciana di Venezia, manoscritti italiani, cl. IV cod. XXVI (5131). A copy of this manuscript in the Archivio di Stato di Venezia (ASV) under the title 'Arte de far vasselli', Archivio proprio Giacomo Contarini. sec. XVI, Miscellanea Codici 373. Manuscript Online: http://echo.mpiwg-berlin.mpg.de/MPIWG:7KTSNYA6.

[5] Units of measurements used in this text are explained in Table 7.1.

[6] This part is written by Arnaud Cazenave de la Roche.

[7] This part is written by Cayetano Hormaechea.

[8] This part is written by Fabrizio Ciacchella.

Table 7.1 Linear and volume measure units for ships mentioned in the article

Origin	Linear units		Volume units	
Venice	*piè (piede)* = 16 *dita veneziane*	0.3477 m	Venetian *botta/botte:* estimated capacity (Lane)	c. 0.600 m^3
	Passo geometrico = 5 *piè (piedi)*	1.7385 m	Estimated weight (Lane)	c. 640 kg
			space occupied in hold = 10 *staia*	0.833 m^3
			Venetian *staio/ster*	0.0833 m^3
Sicily			*Salma generale*	0.2655 m^3
Naples			*Carro* = 36 *tomoli*	1.9915 m^3
Genoa[a]	*Palmo di canna* = 12 *dita genovesi*	0.2478 m	*mina* = 4 Genoese *staja* (1310–1550)	0.1058 m^3
			(after 1550)	0.1121 m^3
	Gobito, chobitto, goa = 3 palmi di canna	0.7432 m	foreign *botte:* estimated capacity	c 0.445 m^3
			space occupied in hold = 2.5 *salme*	0.6638 m^3
			Corresp. Weight = 10 *cantari*	476.5 kg
Spain			*Pipa andaluza: capacity*	0.4437 m^3
			Space occupied in hold = 4 cubic *codos castellanos* or 4 cubic *codos de ribera* (according to different estimates)	0.691–0.761 m^3
	Codo castellano = 32 dedos	0.557 m	*Tonelada de carga / tonel castellano = space occupied by 2 pipas andaluzas = 8 cubic codos castellanos*	1.382 m^3
	Codo de ribera = 33 *dedos*	0.575 m	*Tonel macho* = space occupied by 2 *pipas andaluzas* = 8 cubic *codos de ribera*	1.521 m^3
	After 1590, all measures were in *Codos de ribera* and *toneles machos*			
Portugal	*Palmo de Goa = 14 dedos*	0.2566 m	*Tonelada* (Portuguese): space occupied in hold = 6 *salme*	1.593 m^3
	Goa, côvado real = 3 palmos	0.77 m		
	Rumo = 2 *goas*	1.54 m^3		

the part that Sagri dedicates to naval architecture is dense. As a result, it allows a fairly precise insight of the architecture of the forms of Ragusan shipbuilding, at least that of the *navi*, the merchant ships of the time. In this sense, Nicolò Sagri‘s text is in line with the Italian tradition, which is characterised by a network of measurements that allow the architectural profile of the *nave* to be set out, but which is, on the other hand, free of any information on the carpentry techniques employed. What is also innovative and original in Sagri's text, compared to those of the fifteenth century Venetian authors, is that the description of his 30-*piè nave* is based, to a large extent, on a set of rules of proportion that link the measurements together (see Table 7.3). Therefore, the application of these proportions to measurements other than those he gives for his example of 30 *piè de larghecza* would—a priori—make it possible to define the profile of any *nave* of other dimensions.

1.1 The Nave

A few words on this typology of ships are necessary before going into detail of the architectural description of Sagri's *nave*. Its origin is not clear, it is said to date back to very ancient times, to the end of classical antiquity, according to Furio Ciciliot (2005, p. 182, 185), but the first written attestations appear at the end of the twelfth century. For his part, Jacques Heers states that this type of ship was introduced in Genoa in the twelfth or thirteenth century by Basque sailors (Heers 1958, p. 109). It should be pointed out that the *navi* were private merchantmen. Although they were described by the fifteenth and sixteenth centuries shipwrights of the Venice Arsenal, they were built in private shipyards (Lane 1934, p. 46). As is the case with most types of ships, their physiognomy has changed significantly over time. In the thirteenth century, the *nave* was equipped with two lateral rudders and carried two masts rigged with Latin sails (Ciciliot 2005, p. 184). From the fifteenth and sixteenth century, its characteristics can be summarised as follows:

– Nautical spaces: Typical Mediterranean merchant ship, it was in use in the trade of all the Italian cities and in Ragusa, but it was particularly used by Genoa, while Venice, for example, turned quite early to the development of merchant galleys, the '*galee grosse da merchato*'.
– Tonnage: The *nave* was a large-capacity vessel, the largest Mediterranean merchant ship (Gatti 1999, p. 145). Her tonnage has evolved over time. It was in the fifteenth century that the largest units specialised in the transport of alum were operating in Genoa. Manlio Calegari points out that in 1509 the average tonnage of *navi* in Genoa was 14.000 *cantari*, i.e. a little less than 670 metric tons of net deadweight and 930 m^3 of net tonnage; and that the smallest units had a tonnage of more than 8.000 cantari, i.e. 380 metric tons of net deadweight and 530 m^3 of net tonnage (Borghesi and Calegari 1970, p. 15–16).
– General characteristics: in the sixteenth century, the *nave* was rigged with three masts with square sails on the foremast and mainmast and a Latin sail on the mizzen mast. It was generally provided with three decks, two *cubiertas* and a *tolda*.[9] Finally, although the *navi* were commercial ships - they were usually armed with several pieces of artillery to enable them to defend themselves against the pirates that proliferated in the Mediterranean.

The model of ship described by Sagri is a *nave* 90 *piè* (90 Venetian feet, i.e.32 m) of length, 30 *piè* (about 10.50 metres) of maximum breadth. With a tonnage of between 2500 and 2600 *salme*, or about 10,000 to 10,400 *cantari*, Sagri's *nave* is therefore situated in the lower part of the average capacity of this typology of merchant ships of the time.

[9] The question of the number of decks has given rise to much confusion. We attempt to clarify it in the part that deals with the horizontal structures of the nave.

1.2 The Relationship Between the Three Main Dimensions of the Ship

The definition of the relationship between the large dimensions of the ship are at the basis of any architectural project and, at the beginning of the modern era, there was a rule of proportion that was widely spread and in use in both Atlantic and Mediterranean nautical spaces, stated under the name of '*As-Dos-Tres'* by Spanish authors. In its first meaning, the maximum breadth is set as a referent (*As*) which multiplied by two gives the keel length (*Dos*) and by three gives the total length (*Tres*) of the ship:

$$\mathrm{B}(As);\mathrm{K}(Dos) = As \times 2; \mathrm{L}(\mathrm{Tres}) = As \times 3. \qquad \mathrm{B} = \mathrm{Breadth}; \mathrm{K} = \mathrm{Keel}; \mathrm{L} = \mathrm{Length}.$$

Thomé Cano expressed this rule most clearly: '…all the Spanish, Italian and other masters of shipbuilding have the practice of giving to one codo at the breadth, two to the keel length; and to another codo at the breadth, three to the overall length, and to three co-dos at the breadth, one to the flat width; and for the depth, three quarters of the breadth' (Cano 1611, p. 15).

We do not know the origins of the *'As-Dos-Tres*'rule, we only know that it is inherited from a long tradition that takes its roots in the early modern era and, in the symbolism of the Renaissance, that is perhaps a religious allegory of the Holy Trinity and/or of the 'Divine Proportion'enunciated in the thirteenth century by the Italian mathematician Leonardo Fibonacci, whose numbers in his famous series begin with 1, 2, and 3.[10]

Some builders of the time stated the rule with a variant which does not retain the dimension of the keel in this triple relation of proportions, but that of the depth of hold. Some authors express the 'As-Dos-Tres'rule, some with reference to the keel, others to the depth of hold, some both, some neither. The only ratio systematically mentioned being that of length/breadth (Cazenave de la Roche 2020, p. 10). For this part, Sagri uses the rule with reference to the depth of hold: 'It is well known that each body [of a ship] has three main measurements, which are length, width and height or depth, without which it would not form a body' (f°13R).

Already in the second folio of his chapter, he advocates a relation of proportion between these three main measures as follows: '...I shall say only [to illustrate] the three principal measurements of this *nave* that you should know that it should be three times as long between the bow and the stern at the level of the second deck as her greatest width at the level of the second deck, and her height or depth which we

[10] Leonardo Fibonacci (1175-c. 1250), a native of Pisa, was the author of the algebraic sequence called 'Divine Proportion'. It is designed as a series of numbers, each of which is the sum of the two preceding ones (1, 1, 2, 3, 5, 8, etc.).

call *pontalle* should be at the level of this second deck half that width, and this is the fairest and best proportion that one can imagine...'(f°13v, L.5 to 15).

This sentence, which we have considered useful to reproduce here, is of a great importance as it defines the basis of the rule of proportion which will govern the main nautical characteristics of the *nav*e. In short, it states that:

$$\mathrm{B}\left(As\right);\mathrm{L}\left(\mathrm{Tres}\right)=3\times As;\mathrm{D}\left(\mathrm{Depth\,of\,Hold}\right)=\frac{1}{2}\times As.$$

To our knowledge, Sagri is the first Mediterranean author to state the *'As-Dos-Tres*'rule and, as we have seen, he does so by taking the variant that establishes the depth of hold as one of the three great measures rather than the keel. After him, but without explicitly mentioning it, Bartolomeo Crescentio expressed the rule in an identical way through the example of a ship whose dimensions he laid out (Crescentio 1602, p. 68). It would be interesting in the future to check whether this formulation breadth/length/depth of hold could be of Mediterranean origin, bearing in mind that, as Cayetano Hormaechea points out, Iberian authors tend to express it with reference to the length of the keel rather than the depth of hold. Notwithstanding this, the issue raised by the evaluation of the proportions stated by the builders who refer to the depth of hold is the vagueness that exists in the definition of this architectural notion because some builders measure it up to the first deck, others to the second or to the maximum breadth, or still others do not specify it. However, Sagri specifies that the depth of hold of his *nave* is measured up to the second deck and that her height is ½ times her maximum breadth. We will come back to this point. The *'As-Dos-Tres*'rule raises several questions:

– One of them concerns the nautical characteristics of ships built with these proportions: In order to determine accurately and completely these characteristics, a study through hydrodynamic calculations would probably be necessary. In the frame of this study we will settle for stating the nautical qualities mentioned by Sagri: according to him, ships of *'As-Dos-Tres*'proportions are 'better than others under sail, they have in particular a good ability to sail upwind' (f°13 V-L.3). Their second quality is that they are manoeuvrable in the sense that 'they respond better to the rudder than others' (f°13 V-L.4). It should be added that a ship whose length is only three times the size of her maximum breadth offers good load capacity and stability to the detriment of its speed. And actually, it is essentially for these reasons that the *'As-Dos-Tres*'rule was favoured for merchant ships.

Several texts bring evidence of the use of the rule in the second half of the sixteenth century in the Mediterranean for merchant ships. For Venice, the merchant *nave* of *piè 20 en bocha* by Theodoro de Nicolò illustrates it with a ratio of 1: 2.17: 3.11, thus very close to the *'As-Dos-Tres*'rule, or the *nave* of *nave de 14 passa en cholonba* by 'Misure di Navilii' which also fits precisely to it. In Genoa, notarial contracts specifying the technical characteristics of the *navi* to be built or sold attest to this (Gatti 1975).

For warships, the situation was often different. In the sixteenth century, with the development of the architectural concept of the battery, ships specialised in a warlike function appeared. Their breadth/length ratio reached 1–4, which reflects a prioritisation of speed over cargo capacity.[11] In the Mediterranean this fact is evidenced in the texts by Theodoro de Nicolò who describes a warship, the '*galeon grande*' of 37 ½ piè of maximum breadth and 20 *passi* (100 *piè*) of keel lengths with a more stretched shape with a ratio of 1: 2.67: 3.6.1[12] Nevertheless, in the last third of the sixteenth century we still see in the Mediterranean war galleons built on the model of the *'As-Dos-Tres*'rule. This fact is documented by an *asiento* between Philip II and the Ragusan Pedro de Ivella dated 1590 for the construction of 12 war galleons made in various Italian and Ragusan shipyards that adopted these proportions (Hormaechea et al. 2012; Casabán 2017).[13] Although forming a war squadron called '*escuadra Ylírica*', when these galleons were not on a war expedition, Pedro Ivella used them for commercial transport tasks. This raises the question whether their still multiple function could have favoured the *'As-Dos-Tres*'rule for their construction. Several texts also evidence the habit of giving a more elongated longitudinal shape to warships, not only in the Mediterranean, but also in the Atlantic area.

Another question also arises regarding the geographical and chronological boundaries that frame the use of the *'As-Dos-Tres*'rule: after stating that these proportions are the 'fairest and best that can be imagined', Sagri specifies '...although few ships today in our country are built in this way, whereas the old ones were built in this way' (f°13v, L.16 and 17). He adds that 'today the Genoese still build them in this way, as do the Biscayans and the Portuguese...' (f°14R, L.1-2). This sentence is important because it confirms that at the time he wrote his work, in 1570–1571, the rule in question was in use in both the Mediterranean and Atlantic areas. In Ragusa, however, it seems to indicate that it was no longer observed as it was before. However, according to the technical characteristics of the ships of Pedro Ivella's fleet of 1590, both those built in Naples and Ragusa had proportions in accordance with the *'As-Dos-Tres*'rule. It can therefore be deduced that 20 years after Sagri's death, it was still in use in Ragusa's shipbuilding. In the continuity of Sagri, at the beginning of the seventeenth century, the Spanish builder Thomé Cano also gave a universal character to the rule in 1611 by stating that it was used by 'all the masters of Spain, Italy and other nations'(Cano 1611, p. 15). In the sixteenth and early seventeenth centuries, both the authors of shipbuilding treatises and archaeology confirm its use in Ibero-Atlantic construction, as we will see in the second part of this chapter.

[11] The laws of hydrodynamics which associate an increase in the speed of movement of the hull with an increase in its waterline length are empirically known in the sixteenth century. They were first theorised mathematically by the British William Froude in the nineteenth century.

[12] 'Instructione sul modo...', *op. cit*., f°26 and 27.

[13] 'Relación de la fábrica de doce galeones de guerra de la Escuadra Yllirica de Pedro de Ivella y Estéfano Dolisti. Carta de Pedro de Ivella al rey, de 17 diciembre 1593'. AGS, Guerra Antigua, Leg. 380–105. Reproduction in MNM. *Colección Navarrete*, Tomo IX, doc. 27, MNM.

In the Mediterranean, the shipwrecks documented to date are of older chronology, located in the first third of the sixteenth century. These are the Lomellina (1516) and the wreck of the Mortella III (1527), both of presumably Genoese construction, and whose longitudinal profiles are more stretched than those recommended by the '*As-Dos-Tres*' rule, with ratios of 1: 2.56: 3.52 and 1: 2.48: 3.50 respectively. These ratios can be compared to those that seem to be in use in Venetian construction in the fifteenth century. In fact, Venetian authors of the period such as Michele da Rodi or Zorzi Trombetta da Modon gave their *navi* similar ratios. These observations must be interpreted with caution, since the paucity of archaeological and textual documentation in the Mediterranean—which is moreover limited to Italian shipbuilding—restricts our field of vision. As a hypothesis, it can be sum up that (see Table 7.2): Between the fifteenth century and the first third of the sixteenth century (Period 1), Mediterranean shipbuilding in its Italian representation -in this case Venetian and Genoese – seems to have given to merchant ships, the *navi*, a stretched longitudinal profile with ratios of around 1: 2.50–2.80: 3.50–3.80.[14]

In the sixteenth century, and in any case after the first third of the century (Period 2), the '*As-Dos-Tres*' rule -expressed in two variants, but whose constant is to link length to width by a ratio of 1 to 3- was in use throughout European shipbuilding, both Mediterranean and Atlantic. However, it applied mainly to merchant ships, while generally more stretched proportions were in use for warships. If Theodoro de Nicolò and Crescentio evidenced it for the Mediterranean, this practice was institutionalised in the Ibero-Atlantic space by Spanish ordinances at the beginning of the seventeenth century. From the last third of the sixteenth century, the period in which Sagri writes, the rule was still widely used, but some nations, such as Ragusa, no longer observed it as strictly as before. In the Ibero-Atlantic area an evolution of proportions also appeared in the same period with the emergence of a movement called the '*Nueva fabrica*'.[15]

1.3 Reconstruction of Shapes Relying on a Network of Secondary Proportions

1.3.1 The Transverse Shape: Depth, Width of Decks, Maximum Breadth and Waterline

From the second folio of his Chap. 6 (f°14 V), Nicolò Sagri addresses the question of the horizontal layout of the hull structures which will allow us to sketch the transverse shape of the *nave* which depends essentially on the depth of hold and width of

[14] It must be outlined that the smaller is the tonnage of a ship, the more her shapes will be stretched. In fact, the '*As-Dos-Tres*' rule is only applicable to medium or large tonnage units.

[15] The '*Nueva fabrica*' is a movement that emerged in Spain in the last third of the sixteenth century under the impetus of builders such as Juan de Veas. It advocated stretched shapes to merchant ships that departed from the '*As-Dos-Tres*' rule. We will return to it in the next part of this chapter.

Table 7.2 Evolution of the ratios in the Mediterranean (15th-16th c)[a]

Period 1: fifteenth to mid sixteenth centuries												
	Michele da Rodi, *'Nave quadra'* c. 1434 (Venice)				Zorzi Trombetta da Modon, c. 1444, (Venice)							
Main measures	Ratios	*Paso*	*Pie*	Meters	Ratios	*Paso*	*Pie*	Metres				
Max. Breadth	1		26 1/2	9.22	1		28	9.74				
Keel length	2.45	13	65	22.62	2.59		72 1/2	25.23				
Length	3.58		95	33.06	3.80		106 1/2	37.06				
Depth of hold	1/2		13	4.52	2/5		11	3.83				
Flat	4/5		9 3/4	7.25	1/3		9	3.13				
Ton.					700 bote							
Source	(Michele da Rodi, 1434)				(Zorzi Da Modon, 1444)							
	'Lomellina' wreck 1516 (Genoa)				Mortella III wreck 1527 (Genoa)				*Nave Santa Trinita* 1548 (Ragusa)			
Main measures	Ratios	*Goa*	Palmi	Metres	Ratios	*Goa*	Palmi	Metres	Ratios	*Paso*	*Pie*	Metres
Max. Breadth	1			12.50	1		42 1/3	10.50	1		27 1/2	9.57
Keel length	2.56			32.00	2.48	19 1/3		26.00	2.36	13	65	22.62
Length	3.52	59		44.00	3.50	49 1/2		36.80	3.42		94	32.71
Depth of hold	1/2			6.70	1/2			5.26	1/2		15	5.22
Flat					1/3			3.45				
Stem overhang	4/5			10.00					2/3		19	6.61
Stern overhang	1/6			2.00	1/6			1.65	1/3		10	3.48
Ton.					12000/13000 cantari							
Source	(Guérout et al., 1989)				(Cazenave, 2020)				(Gatti, 1975, p.93)			

Period 2: Mid-sixteenth to seventeenth century												
	Nave 20 pie Theodoro de Nicolò 1550 (Venice)				*Nave* 14 passo in cholonba' Misure di Navilii 1567 (Venice)				Sagri's *Nave* 1571 (Ragusa)			
Main measures	Ratios	*Paso*	*Pie*	Metres	Ratios	*Paso*	*Pie*	Metres	Ratios	*Paso*	*Pie*	Metres
Max. Breadth	1		23	8.00	1		34 1/2	12.01	1		30	10.44
Keel length	2.17	10		17.40	2.03	14		24.36	1.94		58 1/8	20.23
Length	3.11		71 1/2	24.88					3		90	31.32
Depth of hold	1/2		11 1/2	4.00	2/5		14	4.87	1/2		15	5.22
Flat	1/3		7	2.44					1/3		10	3.48
Stem overhang	2/3		15	5.22					4/5		24 3/8	8.48
Stern overhang	2/7		6 1/2	2.26					1/4		7 1/2	2.61
Ton.									2500/2600 *salme*			
Source	(Theodoro de Nicolò 1550)				(Nicolardi 2014)				(Sagri 1571)			
	Calvi I wreck 1580/1600 (Genoa?)				*Nave* by Andrea Fava 1599 (*Santa Maria in Betelen*, Genoa)				*Nave of* pie 30 Crescentio 1602			
Main measures	Ratios	*Goa*	Palmi	Metres	Ratios	*Goa*	Palmi	Meters	Ratios	*Paso*	*Pie*	Metres
Max. Breadth	1	10 1/2		7.80	1		39	9.67	1		30	10.44
Keel length	2.18	23		17.00	2.31			22.33	2		60	20.88
Length	3.19	32 1/4		24.90	3.23	42		31.25	3	18	90	31.32
Depth of hold					4/7			5.45	1/2		15	5.22
Flat									2/7		9	3.13
Stem overhang	2/3			5.10	3/5			5.70				
Stern overhang	1/3			2.80	1/3			3.22				
Ton.					3000 salme				2565 salme			
Source	(Villié, 1989–1991)				(Gatti, 1975, p.72; 1999, p. 287-9)				(Crescentio, 1602, p. 70, 75)			

[a]Ratios are referred to the beam. Lengths and depth of hold are measured to the second deck

the decks. In the Italian shipbuilding tradition, the transverse shape of the ship was obtained by a scale of values, or offset, defined by the relationship between heights taken on several lines running above the keel (ordinate) and the breadth between the frames at these levels (abscissa). The first two heights, called '*trepiè*' and '*seipiè*', located, respectively, three and six *piè* from the '*tavola*', correspond to hull breadth values. Then comes the breadth at the level of the '*bocha*', which under the pens of the fifteenth century authors such as Michele da Rodi or Zorzi 'Trombetta' da Modon, corresponds to the line of the maximum breadth. But in the sixteenth century, under the pen of Theodoro de Nicolò, the *bocha* corresponds to a depth of 9 *piè* and the line of the maximum breadth takes the name of '*Regia*'. Finally, the scale of values is completed by the relationship between the heights and breadth of the decks. In the system proposed by Sagri, only the latter relationship is given, the concepts of *trepiè*, *seipiè,* and *bocha* are not mentioned.

The Number of Decks Before addressing the question of the relationship between the height/width of the decks, it is useful to point out that their number often gives rise to confusion due to the different ways in which the first transverse reinforcement structure of the hull can be considered. Indeed, depending on the constructive tradition, this may consist of a series of beams that structurally connect the two sides of the hull without necessarily being decked (or sometimes provided with a removable floor). In English the latter takes the name of orlop. In Spain, the authors speak of '*baos vacíos',*[16] the French authors of '*faux pont*' and, in this case, it is only the second transverse structure, the one with a fixed floor, which is called the 'first deck'. This semantic aspect can lead to confusion, and Italian shipbuilding, whose horizontal internal structures of the hull are called '*choverta*', '*coverta*', or '*coperta*', is no exception. The last and highest is called '*tolda*' (upper deck, '*puente*', in Spanish; formerly '*tillac*', in French). The numbering of the decks may therefore vary depending on the way the authors express themselves. For example, Luciana Gatti characterises the *navi* as a typology of ships usually with two decks (Gatti 1999, p. 146). But by two decks, it is necessary to understand here either two '*choverta*', without taking into account the 't*olda*', or two decks, independently of the orlop we have mentioned, which is sometimes overlooked in the description of the *navi*. For example, Gatti (1999, pp. 288–289) reproduces a construction contract dated 1599 for a *nave* with dimensions close to those of Sagri. The notary mentions the height of the first deck: '*Altezza prima coperta'* = 5.45 m. The structural need for an orlop between this deck and the ceiling is obvious, but it is not mentioned.[17] In general, we are dealing with a typology of ship with three transversal structures and, which is the case of the Sagri's *nave*: In his text, he mentions a '*prima cho-*

[16] This Spanish terminology expresses the absence of a deck. In the remainder of this article, it will be referred to as 'naked' beams.

[17] Archivio di Stato di Genova (ASG), Notai antichi, Rivanegra Abramo filza 26, Genova, 8 Aprile 1599: Contract dated 1599 for a *nave* with dimensions close to those of Sagri.

vertta', a '*sechonda chovertta',* and a '*tolda*'. From a certain tonnage, in addition to these three decks, there was in addition a '*ponte di corridoio*' or orlop.[18]

As we shall see, in the example given by Sagri, the main reference used to determine the depth of hold and the maximum breadth is the '*sechonda coperta*' under which he specifies that the cargo is located when it consists of grain: 'The so-called second deck must be the one under which the entire cargo of this *nave* can be stored when it is composed only of grain'.

Height of the Decks Sagri explains a rule of proportion that allows to locate the height of the three decks of his *nave*: 'This depth, …we call *pontalle*, must be divided into five parts, three fifths of which will go from the bottom to the first deck, and the remaining two will be between these two decks [first and second deck]' (f°14 V, L9 to 13). '... we will have 27 ½ piè from the bottom of the *nave* to the upper part of the bulwark in the middle of the upper deck of this nave' (f°15 V, L3). This distribution makes it possible to locate the first deck at a height of 9 *piè* (3.13 m), the second at 15 *piè* (5.22 m), the third deck (*tolda*) at 22 ½ *piè* (7.83 m) and finally the total height at the bulwark of 27 ½ *piè* (9.57 m).

Breadth of the Decks and the Flat (at Mid-Ship) The first deck: At f°14 V, Sagri gives the proportion to set the width of the first deck: 'The width of the first deck will be three times its depth of hold' (14 V, L16 and 17). He returns to this measure in f°16R where he states: 'its width at the first deck will be 27 *piè*'.

The second deck: its width is part of the '*principali mesure*' stated above; it is equal to 30 *piè* (10.44 m) and also represents the line of the maximum breadth.

The third deck (*tolda*): its width is not mentioned, but in the logic of the transverse shape mentioned by Sagri, it must be a little bit less than the first deck.

The flat: the width of the flat, '*piano*' or '*fondi*', is set by the following ratio of proportions: 'the flat is 1/3 of its width [of the deck], or 3/5 of the depth of hold and as much the runs' (f°14 V, L13). Note that the first proportion corresponds to a value of 9 *piè* (3.13 m) and the second 10 *piè* (3.48 m). Nevertheless, a little further on in the text (f°16R, L1), Sagri specifies that the flat of his *nave* is 9 *piè*. As we saw, he states that at the stern, the height of the run is also 9 *piè* (f°16R, L5). On the other hand, he does not specify anything about the transverse shape of the master-floor. We do not know whether it has a strong rising as archaeology has revealed in the Genoese shipbuilding (Cazenave de la Roche 2020, pp. 118–122) or whether it is flat, as in the Iberian shipbuilding tradition. In our reconstruction of Sagri's master-frame, we have opted for a hypothetical intermediate shape (Fig.7.1a).

Finally, he provides information that determine the width of the transom and place the waterline at the height of the second deck once the *nave* is loaded: 'the [distance between the] fashion timber at the level of the heads of the first wale of the

[18] For example, in the Ragusan construction, we can cite Pedro de Yvella's '*assiento*', mentioned above. Indeed, the characteristics of the galleons explicitly mention the presence of '*baos vacios'* under three decks: the two '*cubiertas'* and the '*puente*'.

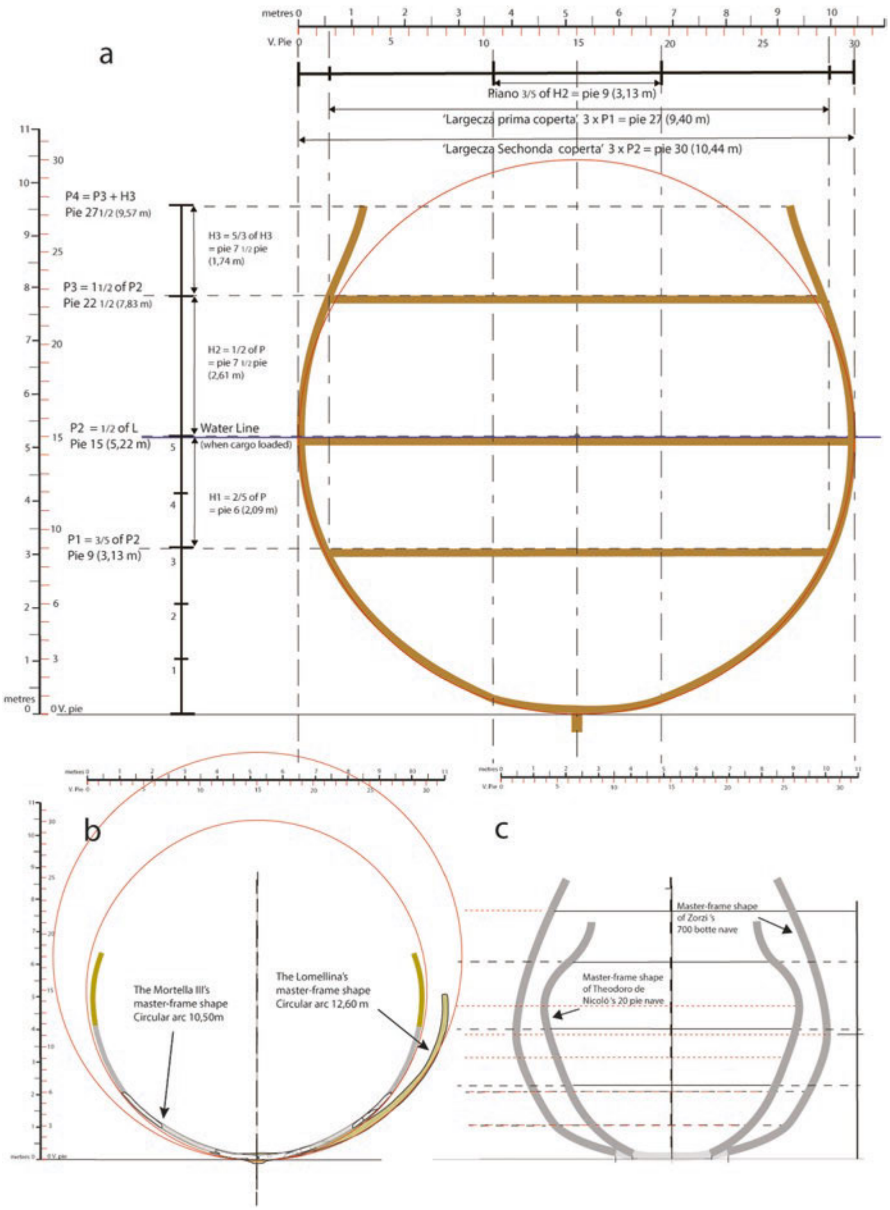

Fig. 7.1 (**a**) Reconstruction of the transverse shape of Sagri's nave; (**b**) Circular transverse shape of the Genoese navi of Mortella III and Lomellina (radii); (**c**) Oblong shapes of the profiles of the Venetian navi of Michele da Rodi and Theodoro de Nicolò. Illustration A. Cazenave

first deck [,] that is to say, where (14 V, L17–19) the waterline will be when the *nave* is loaded, must be half this width [of the first deck]' (15R, L1–2). As a result, the transversal shape of Sagri's *nave* can be reconstructed as follows:

The transverse shape of Sagri's *nave* highlighted by the proportions set out in his Chap. 6 reveals a circular profile following a radius of 5.22 m. It can be compared to the shapes observed on the Genoese wrecks of Mortella III, Lomellina and also Calvi I, whose origin is, however, less formally established. In this sense, the transverse design of Sagri's *nave* appears closer to the typology of form highlighted by archaeology in the Genoese shipbuilding than the shapes disclosed by the Venetian texts of Michele da Rodi or Zorzi da Modon, for the fifteenth century, and Theodoro de Nicolò, for the sixteenth century, whose profiles are more oblong with a tendency towards ellipsoidal shape (Fig. 7.1b, c).

In fact, Venetian shipbuilding is characterised by transverse profiles that make several arcs of tangent circles coexist. However, in the fifteenth century these shapes were not obtained by the projection of circular arcs, but by an arithmetic construction with a scale of values that we mentioned earlier. The geometrical construction of the transverse form using tangent arcs of circles appeared -to our knowledge- in the middle of the sixteenth century with Theodoro de Nicolò. Without abandoning the scale of the '*trepiè'*, the 's*eipiè',* and the '*bocha*', he, however, used for the first time an '*ano de valangin dal magier de bocha fin a la tolda*' ('circle arc from the beam of bocha to the *tolda*') and another '*ano de valangin dal fondi a la bocha*' ('circle arc from the floor to the *bocha*'). This design the master-frame shape with tangent arcs of a circle of Venetian origin influenced English shipbuilding, which took up and developed it in the last third of the sixteenth century (Cazenave de la Roche 2020, pp. 13–22). It is described by Mathew Baker in his 'Fragments of Ancient English Shipwrightry'.[19]

Thus, although located in the Venetian zone of influence, the transversal architecture of the Ragusan *nave* highlighted by Sagri seems to be different from that advocated by the Venetian texts we know. On the other hand, it is similar to what archaeology has taught us about Genoese architecture, but also to that of the Iberian world, where the single arc of a circle was widely used to give shape to the master-frame. Iberian authors widely advocate the use of a single arc of a circle for the design of the transverse shape of merchant ships (Hormaechea et al. 2012, p. 186; Cazenave de la Roche 2020, pp. 13–15).

Rake of the Stern It is given by a simple proportion: 'for every *piè* of vertical height, half a *piè* of overhang will be given' (F°15R, L2–4). This ratio, illustrated in the manuscript by a small sketch in the margin (F°15R), results in a rake for about 65° to the horizontal (exactly 63.43°, calculated by trigonometry).

[19] Mathew Baker, *c.*1580, 'Fragments of Ancient English Shipwrightry.' Cambridge, Magdalene College, Pepysian Library, Ms. 2820.

1.3.2 The Longitudinal Shape

Shape and Overhang of the Stem Sagri set out a system of his design to define the shape and overhang of the stem: 'I advise that we follow a new way that I have found, which consists in taking the height of the *nave* from the ceiling to the last wale [,] that means, to the path of the gangway at mid- upper deck and we draw in a line as long as the said height will be [...], ... then at one end of this line a compass point will be placed and the other point at the other end of this line, and with this opening, a circle will be drawn inside which the fourth part will be taken, which will constitute the bow' (f°15R, L4–17). In short, Sagri is using a circular arc whose centre is located at the intersection of the horizontal line of the upper deck (*tolda*) with the vertical line passing through the fore end of the keel (Figs. 7.2 and 7.3).

Regardless of the 'new method' that he exposes, Sagri specifies that 'in the past', the builders gave the bow two *piè* of overhang to each *piè* of depth and that 'today' they give an overhang of only one *piè* and 2/3 at each *piè* of depth (F°15R, L4–5). In fact, the Sagri system produces a result very close to that in use at the time when he was writing.

The Curvature of the Wales The wales (*centa* or *zenta*) are external longitudinal reinforcements essential to the structure of the hull. In the last part of his chapter Sagri describes in detail their positioning and their curvature (*archamentto* and *cerviecza*) which helps to understand its shape: At mid-ship, the two first wales are

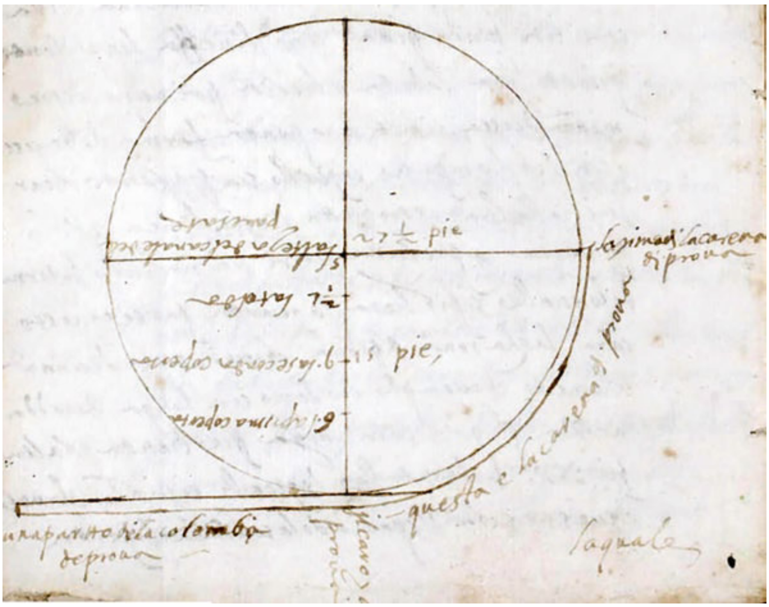

Fig. 7.2 System set out by Sagri to design the stem-post (F°15 V)

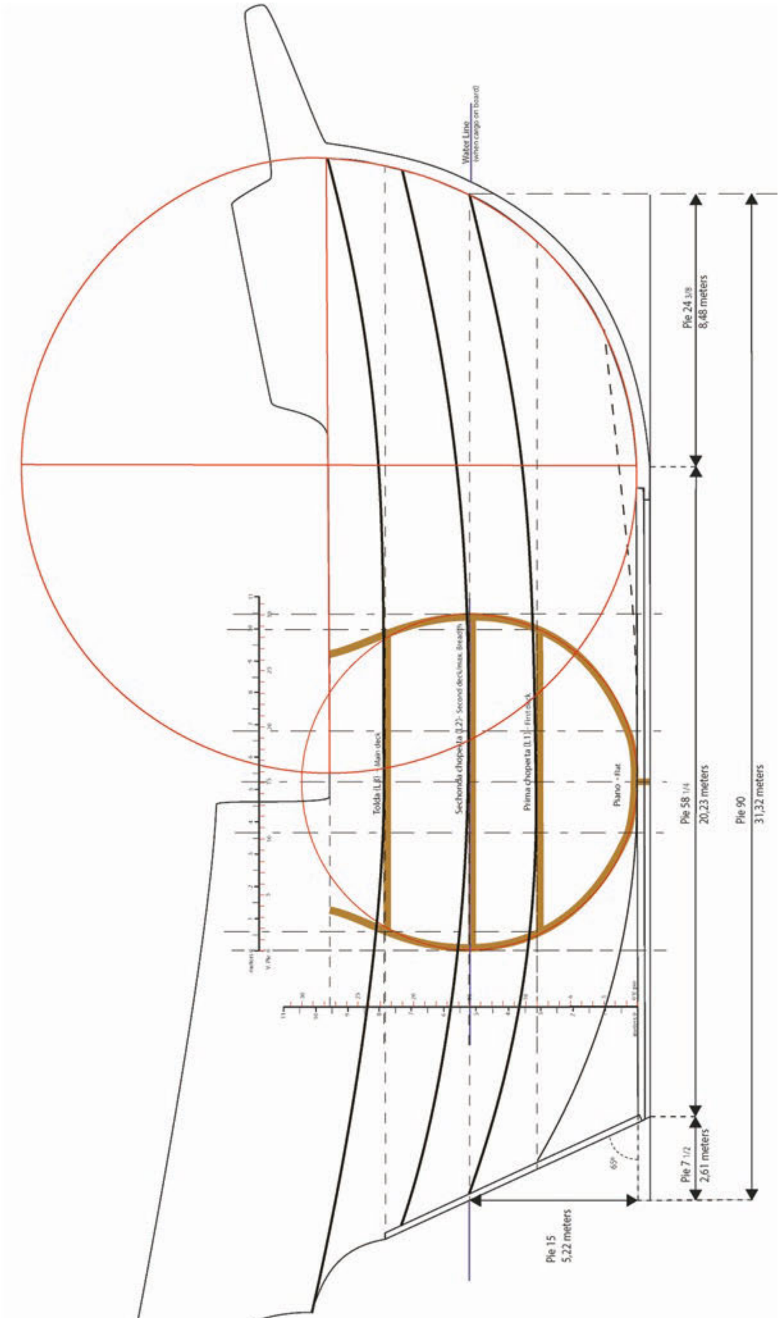

Fig. 7.3 Reconstruction of Sagri's nave longitudinal shape and dimensions. Illustration A. Cazenave de la Roche

located, respectively, at the level of the first and the second deck. The space between them is therefore 6 *piè* (f°16R, L14–16, f°16 V, L1). They continue their course towards the bow and the stern as follows: the heads of the first wale reach the level of the second deck. As for those of the second wale, they are located at a distance of 6 *piè*, but this time not measured vertically, but according to a sloped trajectory. At the stern, it follows the line of the fashion timber and at the bow, the line of stern, so that the two wales come closer at the end of their course (f°16 V, L10–14).

In the end, the longitudinal shape of the ship reconstructed following Sagri's indications can be represented as in Fig. 7.3. Measures and ratios are given in Table 7.3.

Table 7.3 Proportions of Sagri's *nave*

	Ratio to depth	Ratio to breadth	Piè	Metres
HEIGHTS				
Bulwark to top of the keel	1 5/6 D2	11/12 B	27 1/2	9.57
Bulwark to third deck (*Tolda*)	2/3 D3		5	1.74
3rd deck to keel	1 1/2 D2	3/4 B	22 1/2	7.83
3rd deck to second deck	1/2 D2		7 1/2	2.61
2nd deck to keel	D2		15	5.22
2nd deck to first deck	2/5 D2		6	2.09
1st deck to keel	3/5 D2		9	3.13
Run	3/5 D2		9	3.13
BREADTHS				
2nd deck	2 D2	1 B	30	10.44
1st deck	3 D1		27	9.40
Flat	3/5 (or 2/3) D2	3/10 (or 1/3) B	9	3.13
Between fashion pieces (at level of the heads of first wale of first deck)		1/2 B	15	5.22
LENGTHS				
2nd deck (water line)	6 D2	3 B	90	31.32
Keel	3 7/8 D2	1 15/16 B	58 1/8	20.23
Overhang stern at bulwark	1/2 D4		13 4/5	4.80
Overhang stern at second deck	1/2 D2	1/4 B	7 1/2	2.61
Overhang stem at bulwark	1 D4		27 1/2	9.57
Overhang stem at second deck	1 5/8 D2	13/16 B	24 3/8	8.48

D1 = Depth at first deck, D2 = Depth at 2sd deck (*pontalle*), D3 = Depth at third deck (*tolda*), D4 = Depth at the top of the bulwark. B = Breadth. Piè = 0,348 cm

2 Mediterranean and Ibero-Atlantic Naval Architecture: A Comparative Study of Two Ways of Building Ships in the Sixteenth Century in the Light of Texts by Nicolò Sagri and Iberian Authors

2.1 Preliminary Considerations

In his Chap. 6 of *Il Carteggiatore,* Nicolò Sagri warns us that, at the time he was writing, the main proportions he proposed for the construction of a merchant ship had already fallen into disuse in his city of Ragusa, but that they were still used by the Genoese, Basques, and Portuguese. This is why we try to contrast the ship he describes with the constructive uses on the Atlantic coasts of the Iberian Peninsula and, in particular, those of Portugal and the Eastern Cantabrian.

As we already saw, the proportions of Sagri's *nave* taken at the level of the second deck meet the '*As-Dos-Tres*' rule, with the depth used as one of the units of reference. However, for purposes of comparison with other Iberian ships, we have taken the length measurement on the upper deck (*tolda*). This means that in the comparison Table (Table 7.4), the Sagri's ratio length / breadth is slightly higher. Something similar happens with the depth. We have decided to maintain Sagri's criteria and we adapted the measurements to reflect the height taken from the flat and not from the ceiling. Finally, Sagri's *nave* is a merchant which presents differences with the Spanish warships. For this reason, we will only compare her with merchant ships.

2.1.1 Criteria for Depth Measurement

There may be significant differences in the criteria used by different authors to establish the dimensions of the hull. It is therefore necessary to make the appropriate corrections to make them comparable. Especially when taking the measurement of the depth of hold which may cause interpretation problems, so we will spend a few lines to clarify that.

Sagri's drawing confirms that the measurement of the depth of hold is taken from the upper face of the keel up to the second deck (f°14 V, Fig. 7.2). However, for comparison purposes, it should be noted that, in the sixteenth century in Spain, two ways of measuring the origin or lower end of the depth of hold were used. Here are some documentary references that perfectly illustrate the above in all their variants: Height from the flat up to the first fixed deck (Escalante de Mendoza 1575, pp. 22–23) and height from the flat up to upper deck: (Oliveira 1580, p. 124; García

Table 7.4 Comparison of the dimensions of the five ships studied

Ships	Sagri–1570 merchant ship		Oliveira 1580 18 *rumos* keel		Luis César 1589 16 *rumos* keel		San Juan 1565 whaling ship		García Palacio 1587 400-*ton*. Ship	
Units	*Pie Venice*	Metres 0.348	*Palmos de Goa*	Metres 0.257	*Palmos de Goa*	Metres 0.257	*Codos de ribera*	Metres 0.575	*Codos de vara*	Metres 0.557
Overall length	96 1/4	33.50	152 2/5	39.17	136	34.95	38 1/5	21.97	51	29.33
Maximum breadth	30	10.44	51	13.11	43	11.05	13 1/7	7.56	16	9.20
Stem overhang	26 3/4	9.31	36	9.25	30	7.71	8 8/9	5.11	11 1/3	6.52
Stern overhang	11 1/4	3.92	8 2/5	2.16	10	2.57	3 5/7	2.13	5 2/3	3.26
Keel	58 1/4	20.27	108	27.76	96	24.67	25 5/8	14.73	34	19.55
Flat	9	3.13	18	6.17	14	3.60	4	2.30	5 1/3	3.07
Run	9	3.13	12	3.08	15	3.86	3	1.72	6 2/3	3.83
Height from flat up to:	Deck		Deck		Deck		Deck		Naked beams	
1st level d./'naked' beams	9	3.13	16	4.11	15	3.86	4 1/2	2.57	4 1/2	2.59
Max. Breadth - waterline	15	5.22	24	6.17	20	5.14	6 2/3	3.85	7 1/2	4.31
2nd level - deck	15	5.22	27	6.94	22 1/2	5.78	7 1/2	4.29	8	4.60
3rd level - deck	22 1/2	7.83	36	9.25	29 1/2	7.58	10 1/2	6.02	11 1/2	6.61
Height between:										
1st and second levels	6	2.09	11	2.83	7 1/2	1.93	3	1.72	3 1/2	2.01
Max. Breadth & second level	0	0.00	3	0.77	2 1/2	0.64	3/4	0.44	1/2	0.29
2nd and third levels	7 1/2	2.61	9	2.31	7	1.80	3	1.73	3 1/2	2.01
Ratios										
Length/keel	1.65		1.41		1.42		1.49		1.50	

(continued)

Table 7.4 (continued)

Ships	Sagri–1570 merchant ship	Oliveira 1580 18 *rumos* keel	Luis César 1589 16 *rumos* keel	San Juan 1565 whaling ship	García Palacio 1587 400-*ton*. Ship
Length/breadth	3.21	2.99	3.16	2.91	3.19
Keel/breadth	1.94	2.12	2.23	1.95	2.13
Stem overhang/keel	0.46	0.33	0.31	0.35	0.33
Stern overhang/keel	0.19	0.08	0.10	0.14	0.17
Depth of hold/breadth	0.50	0.47	0.47	0.51	0.47
Depth at third level/breadth	0.75	0.71	0.69	0.80	0.72
Run/depth at breadth	0.60	0.50	0.75	0.45	0.89
Flat/breadth	0.30	0.35	0.33	0.30	0.33

de Palacio 1587, p. 90). Height from the ceiling planking up to the maximum breadth[20] and height from the ceiling planking up to the second deck.[21]

This way of measuring the height from the ceiling planking, above the floor timbers and not from the flat, was the official way to set the depth of hold. In 1590, it was included by Cristóbal de Barros in the *Cédula de Arqueamiento de Navíos* (Spanish gauge rule for ships) of that year. From this date onwards, the way in which this was done was officially formalised: from the ceiling planking to the maximum breadth, and not to the deck.

2.1.2 Vertical Distribution of Spaces

The horizontal divisions of a sixteenth century ship could be of two types:

[20] 'Informe de Cristóbal de Barros sobre cómo han de ser los galeones a construir en Guarnizo y cómo eran los de Pero Menéndez de Avilés', 19 marzo 1581; MNM, Colección Navarrete, Tomo XXII, doc. 76, f° 292v° a 296v°; 'Relación del maestre Domingo de Bustrurria (...) en lo tocante a los arqueamientos de naos que se toman para el armada en esta costa de Biscaya...'. 1568. AGS, G. A., Legajo 347, n° 23, f°1–2; 'Cédula de Arqueamiento de Navíos', 1590. MNM, Colección Navarrete, T. I, N° de catálogo 789, f°169.

[21] Juan Cardona, 'Memorial que dio Juan de Cardona a su Majestad sobre los doce galeones que hacen en Santander y Bilbao. 24 febrero 589 GS.' 1589. AGS, Guerra Antigua, Legajo 245, f°11.

– Fixed decks and ‘naked’ beams. Fixed decks could be located below and above the waterline.
– ‘Naked’ beams were only located in the hold.

The ship described by Sagri did not have an orlop. She only had three fixed decks. The first of these was situated at a height of 9 *piè* from the flat, the second at 15 *piè,* and the third or upper deck at 22 ½ *piè*. On the other hand, the maximum breadth was situated at the height of the second deck and the maximum height of the waterline as well. The depth on the second deck was therefore 15 *piè*, which means that the first deck was at a height of 3/5 of the depth, leaving 2/5 between decks, i.e. 6 *piè*. The third deck, called *tolda*, was 7 ½ *piè* from the second one.

Oliveira states that the minimum distance between decks must be 7 *palms de goa* (1.80 m) which is the average height of a man, and a maximum of 10 *palmos*, because a man will find it more difficult to get up and down. Besides, with so much separation between decks, the ship will not be as strong. In this way, depending on their size, the ships could have one, two or three decks, and even have a first level with ‘naked’ beams in the case of the larger ones (Oliveira 1580, p. 127). Oliveira recommends setting the first deck at a height of one third of the keel. His criterion, therefore, is very different with that of Sagri.

In Spain, in the sixteenth century, the most common vertical distribution of the interior space of the ship consisted of a first deck below the waterline, called the orlop, and one or two more decks above the waterline, i.e. in the upper works. However, this distribution was sometimes modified by replacing the first deck with ‘naked’ beams, which fulfilled a structural function. The two upper decks were kept, the first of which was usually situated near the maximum breadth, a little higher or a little lower. The second deck, generally situated at a height of 3 or 3 1/2 *codos* (from 1.70 to 2 m) with respect to the first, was called the *puente*.

One of these two criteria was generally used to set the heights of the decks located below the waterline: In some cases, the dimensions of the goods to be transported were taken into account in order to optimise the loading capacity as much as possible. It was not the same to transport only wine barrels as to transport wool, nor was it the same to house troops in the orlop deck as to stow goods. In other cases, some pre-established rules were applied to the way the height was distributed.

2.1.3 Some Technical Characteristics

The Stem and the Fore Overhang In the shapes drawn by Sagri, overhangs are conditioned by the peculiar design of the stem. He states that he designed a new system using a tangent circumference to the bow end of the keel with a radius equal to the height of the upper edge of the bulwark, with respect to the flat. The result is that the maximum fore rake is located at the same height as the bulwark and its length is equal to the radius of the circumference, i.e. 27 ½ *piè.*

In the Iberian Atlantic area, this practice was completely unknown. Oliveira draws the stem with a keel length already defined. He sets the height of the *conves,* or upper deck, to one third of the keel. At the fore end of the keel, he traces a quarter of a circumference tangent to it, with a radius equal to the height of the *conves*, that is, one third of the keel (Oliveira 1580, p. 82). The resulting overhang at the height of the *conves* is equal to the radius of the circumference used, which is 1/3 of the keel, although he admits that the mentioned radius can be shortened by two *palmos* when it comes to a merchant ship. On his side, García de Palacio follows a procedure similar to that of Oliveira, using the third of the keel to determine the height of the upper deck and the fore overhang (García de Palacio 1587, p. 92).

The Stern Overhang Sagri establishes that for every *piè* of vertical height, there will be 1/2 *piè* of overhang. This is as much as saying that the stern overhang will be 1/2 of the bow's one. In this aspect, García de Palacio totally agrees with Sagri, but it should be noted that the drawing of the side elevation of the 400 *toneladas* ship that García de Palacio includes in his work does not conform to what is said in the text. On the contrary, Oliveira establishes the stern overhang at 1/4 of the fore's one.

The Flat Sagri gives two different versions. He says that it has to be 1/3 of the breadth or 3/5 of the depth, which is equivalent to 3/10 of the breadth. This detail must be taken into account so as not to confuse the reader, but for practical purposes we can say that it is the same as what all the Spanish authors of the time we have consulted indicate, that is to say 1/3 of the breadth.

Width of Decks Sagri states that the width of the first deck is equal to three times its height above the flat, and the width of the second deck is twice its depth. On the other hand, he does not give any information concerning the third deck. This layout differs from one of the Oliveira and García de Palacio. Oliveira is rather vague and states that the height on the *conves,* or upper deck, should be approximately 1/3 of the keel, while its width, or *boca*, should be a little more than its height. But then he gives the example of the ship with a keel of 18 *rumos* with a height in the *conves* of 6 *rumos* and a width, or *boca*, of 8 *rumos* (6 + 2) which is quite different (Oliveira 1580, p. 71). To obtain the width of the other two decks, it is necessary to use graphic interpretations.

García de Palacio is a somewhat different case, because he draws no deck below the waterline, but rather 'naked' beams. This reduces to two decks, which correspond to the second and third of Sagri (García de Palacio 1587, p. 90). To make things more complicated, the drawing of the master-frame shows that both decks have the same width, equal to half a maximum breadth. As in the case of Oliveira's designs, we must resort to graphic interpretations.

The Wales Sagri describes two wales that had a strong curvature: The first one had its centre at the level of the first deck. Its ends were at the same height as the second deck. The second wale had its centre at the level of the second deck and its ends did not rise as much as the first wale of the first deck. This means that the first wale was almost completely submerged.

García de Palacio's 400 *toneladas* ship had three wales. The first had a height of 10 *codos de vara* at mid-ship and 16 *codos* at its bow and stern ends. The second was placed half a *codo* higher, and the third other half a *codo* higher, i.e. a total height of 11 ½ *codos*, according to the author, although two pages before he said it was 11. The second deck, or upper deck, was placed at this height. Since the waterline was located at 7 ½ *codos* high, the first wale was located 2 ½ codos higher. It is difficult to imagine a situation more different from Sagri's *nave*.

On his side, Oliveira states that the wales should stick out two *dedos* from the planking and should have a square section. The first should be placed a little lower than the first deck. From there upwards, all those that fit up to the *conves*, three in three *palmos*. No wales were placed under the first deck (Oliveira 1580, p. 138). Since the first deck is 16 *palmos* away and the third is 36 *palmos* away, the wales are distributed over 20 *palmos*. This means that seven wales are placed. It is clear that the ship described by Oliveira has at least three wales below the waterline. This makes it much more similar to Sagri's ship than that of García de Palacio.

2.1.4 The Proportions of Sixteenth Century Merchant Ships in the Iberian Atlantic

Concerning the proportions, Sagri proposes the *As-Dos-Tres* rule in the version that takes the depth as one, the breadth as two, and the length as three. It does not mention the keel: It takes the depth measured from the flat to the second deck which is located precisely at the same height as the waterline (f°13). We will now examine how these proportions were treated in the Iberian context.

In Portugal, the basic dimension to which all the others referred was the keel. In Spain, Escalante de Mendoza also took the keel as the basis for his main proportions, which he thus established this way: every 5 *codos* of keel, 2 1/5 of breadth, and 7 of length (Escalante de Mendoza 1575, p. 22). This is equivalent to putting 2.3 *codos* of keel and 3.2 *codos* of length for every 1 *codo* of breadth, which represents a little more than the *As-Dos-Tres* rule. García de Palacio (1587) also took the keel as a reference and recommended that the depth should be a third of the keel and the breadth almost half of the keel (García de Palacio 1587, p. 90). On the other hand, the breadth was the reference dimension in the Bay of Biscay.

However, whatever is the dimension taken as a reference; there is no reason to modify the final proportions between them, which could be similar to those of other nautical areas. The significant point in the examples cited is that the keel appears as one of the main dimensions, which is not the case with the As-dos-Tres rule cited by Sagri. It was not until the seventeenth century that official regulations or standards appeared to regulate this kind of thing, but there were deeply rooted traditions in wide geographical areas. These traditions could have certain local particularities that differentiated the ships of a certain place from others in the same cultural area.

General Diego Brochero described the *As-Dos-Tres* rule in the same way as Sagri had done (Rodríguez Mendoza 2008).[22] Brochero served for a long time in the galley squadrons of Malta, Naples, and Sicily. Captain Thomé Cano defined the *As-Dos-Tres* rule in 1611 by stating that at 1 *codo* of breadth corresponds to 2 *codos* of keel and 3 *codos* of length. He added that the flat must be equal to 1/3 of the breadth and the depth equal to 3/4 of the breadth (Cano 1611, p. 15). The curious thing is that he claimed that this formula was the one used by all the Spanish, Italian, and masters of other nations. Sagri said the same by stating his rule, but it is evident that both rules do not say the same thing, far from it.

It is curious that before these two opposite versions of the *As-Dos*-Tres rule were exposed in 1570, Rodrigo de Vargas had already exposed a formulation that synthesised the two (Casado Soto 1988).[23] He defined the *As-Dos-Tres* rule by stating that at 30 *codos* of keel correspond 15 in breadth, 45 in length, and 7 ½ in depth. This suggests the idea that the statements of Sagri and Cano were adaptations to the local convenience of the more general rule set out by Rodrigo de Vargas.

In the Bay of Biscay, the proportion that related the depth to half a breadth was not used. Instead, the most suitable depth was chosen for each type of sailing or to optimise the load capacity in barrels. The first reference that we know about this point is given by the master Domingo de Busturia who explains the rule of ‘three to one’ for the merchant ships built in Biscay: for 1 *codo* of breadth, 3 of length, which coincides with Sagri.[24] But Busturia, in addition to stating the rule of ‘three to one’ for merchant ships, adds his opinion regarding the depth at the maximum breadth. According to him, a good proportion would be half a breadth plus a *codo* or *codo* and a half (f°2). This detail already reveals a fundamental characteristic of Cantabrian construction that distances it from the *As-Dos-Tres* rule applied by Sagri, which considers the depth to be *As*, making it equal to half a breadth.

We could quote more definitions from other authors stating the *As-Dos-Tres* rule, but they would not bring anything new. They are all interpretations on the same matter, where the magnitude that varies the most is the depth. These differences concern both its size and the way it is measured.

Usually, the dimension of the depth taken to apply the above-mentioned rule was the height of the maximum breadth or the deck that closed the hold. But we have to be very careful when interpreting the texts because when they quote the depth, without mentioning how far it is measured. Some authors place it at the maximum breadth, others at the deck and finally others at the upper deck. Taking into account all these documents, we find that the depth could be between 1/2 and 2/3 of the width. Everything seems to indicate that when the depth exceeds 2/3 of the breadth it means that it is measured up to the upper deck. This is the case of the depth

22 ‘Decreto del Consejo de guerra sobre los inclusos papeles que trajo el Señor Diego Brochero Anaya tocantes a la nueva ordenanza de navíos. 1607, 1613, 1618,’ AGS. Guerra y Marina, legajo 776 (8-10-1612), f°4.

23 ‘Apuntamientos de Rodrigo de Vargas’. 1588. AGI, Real Patronato, leg. 260, 2°, r° 35.

24 ‘Relación del maestre Domingo de Bustrurria (...) en lo tocante a los arqueamientos de naos que se toman para la armada en esta costa de Biscaya...’ 1568. AGS, G. A., Legajo 347, n° 23.

proposed by Thomé Cano as 3/4 of the breadth. Obviously, this way of measuring the depth is not useful to see if the proportions of the *As-Dos-Tres* rule are met or not. It is generally accepted that the depth should be calculated up to maximum breadth. However, the exact proportions are not found in any document that mentions a ship actually built.

As a summary we can say that in the last third of the sixteenth century Spain did not have any standardisation of proportions for merchant ships. Despite this, there were no major deviations from the *As-Dos-Tres* rule either, except in some Cantabrian ships and the Portuguese *naus da Índia*.

2.1.5 Comparative Table of Dimensions of Sagri's Ship Vs. Atlantic Ships

The Whaling Ship ***San Juan*** In 1978, a shipwreck was discovered in Red Bay (Canada), apparently corresponding to the Basque whaling ship *San Juan*, sunk in 1565. This very interesting ship was the object of a complete archaeological study whose results have been published by Parks Canada in a large 5 volume monograph from which we have obtained the data (Grenier et al. 2007, p. 27,29,54,57,59,143,153 vol. III). It should be noted that, in the monograph, the heights or depths are measured from the lower face of the keel, so to obtain the corresponding heights from the upper face of the keel, in our Table 7.4, 25 cm have been subtracted. On another subject, Brad Loewen and the archaeologists who studied her believe that this ship has a transversal shape with four arches, which brings her closer to the design of the Englishman Mary Rose.

Ship Described by García de Palacio García de Palacio explains to us in his *Instrucción Náutica* that the depth of a 400 *toneladas* boat should be 11.5 *codos de vara* or *castellanos* measured from the keel to the second deck or upper deck, being approximately 1/3 of the keel which was 34 *codos,* while the maximum breadth measured 16 (García de Palacio 1587, p. 90). This ship had a particular characteristic compared to most ships of the time: instead of having the first deck below the waterline, it had 'naked' beams in order to be able to stow barrels up to the first deck located 3 *codos* higher, as we have just seen. On the other hand, the text is accompanied by a drawing of a side elevation of the 400 *toneladas* ship, which shows the following approximate differences from the text: It was 48 *codos* length compared to 51 *codos* in the text. Her fore overhang was 8 *codos* compared to 11 1/3 *codos* in the text.

These differences are approximate because the drawing does not allow for precise dimensions. However, it is clear that with these dimensions the ratio length / breadth is 48 / 16 = 3 exactly. This incoherence, together with other minor ones, among figures quoted in different parts of the work, makes us to think that García de Palacio used information from different origins to document it. It could also be due to the fact that the author's original idea was to describe the ship of the drawing and then decided to add 3 *codos* to make her also suitable for war.

Ship Described by Oliveira In various passages of his *Livro da fábrica das naus*, Oliveira repeatedly refers to the *nau de 18 rumos of* keel which he considered to be a kind of representative prototype of the Portuguese sea-going ships industry. In this section we will follow the dimensions set out in the eighth chapter dedicated to merchant ships.

On page 70 of his work, Oliveira gives a somewhat imprecise explanation of what the proportions of the ships should be. According to him, the height of the *conves* or upper deck should be approximately equal to 1/3 of the keel or a little more, while the width or *boca* at the level of the *conves* should be a little greater than the height. The table shows the data provided by Oliveira, between text and drawings, on pages 71, 79, 81, 99, 124, and 125 of his cited work. Finally, on pages 128 and 129 he mentions the vertical distribution of the ship.

It should be remembered that Portuguese ships of this period usually had an orlop or first deck halfway between the flat and the beam, i.e. more or less in the same place as the Spanish ships had 'naked' beams. It is important to take this detail into account because it can generate confusion when talking about the first or second deck, because they do not mean the same thing to Spanish and Portuguese Treaties authors.

Ship Described by Luis César On November the 22th 1588, the King ordered Juan de Cardona, member of the Council of War, to build 12 galleons in the Bay of Biscay. Cardona consulted various experts. Among those who gave their opinions were Luis César, *Provedor dos Armazéns da Guiné, da Índia e das Armadas de Lisboa*. In a memorandum dated 10 January 1589, César sent to Cardona the specifications and measurements for the building of two types of galleons: one with 18 *rumos* keel and another with 16 *rumos.*[25] It should be noted that the measures provided by Luis César corresponded to ships that were actually being or had been built in Lisbon because he also offered to send a set of 'forms made', i.e. the templates needed for the construction.

2.1.6 Summary Table Comparing Data (Table 7.4)

Preparing a table of dimensions that have been taken in different ways requires a standardisation to make them comparable. In this case we unified two criteria:

– Heights are measured from the flat.
– Lengths are measured on the upper deck.

In the case of the ship described by Sagri, the ratio length / breadth appears to be slightly greater than 3. If the length had been expressed as measured on the second deck the ratio would be three exactly.

[25] 'Relación que dio Luis César de las medidas y gálibo que han de llevar los doce galeones a fabricar por Juan de Cardona.' 1589. AGS, Guerra Antigua, Legajo 245, f°11[CH1], f°72 and 74.

We have prepared a table that summarises the data we have discussed above. To avoid problems of comparison in the table we quote levels as García de Palacio does, instead of decks. Doing it this way, the 'naked' beams will become the first level, the first deck will be the second level, and so on. This only affects the ship described by García de Palacio; in other ships the number of levels is the same as the number of decks.

In order to make a valid comparison, we have written down the length on the third deck in the summary table. Length / keel and length / breadth ratios of Sagri's *nave* exceed those of the other ships which are compared with. In our opinion this is due to the method he used by to design the stem.

As far as depths at the maximum breadth are concerned, they all meet or come very close to the ratio of the *As-Dos-Tres* rule (depth = ½ of the breadth).

The distance separating the second level from the maximum breadth, or maximum limit of the waterline, varies between 0 cm on Sagri's ship and the 64 cm on the one described by César (approximately 2 ½ *palmos de goa*).

Finally, the flat oscillates around 1/3 of the breadth in all of them.

2.1.7 The '*Nueva Fabrica*' ('New Shipbuilding') of Juan de Veas and the Ordinances of the Beginning of the Seventeenth Century

At the beginning of the seventeenth century an important novelty in Spanish shipbuilding occurred: the almost total separation between design and production. This phenomenon was due to the publication of the first o*rdenanzas de fábricas* (Shipbuilding Ordinances) of 1607, 1613, and 1618 intended to regulate and standardise the construction activity.

This transforming task was promoted by General Brochero who relied on two of the best builders of the time: Captain Juan de Veas and Diego Ramírez: Veas, who was the Master Mayor of the Royal Factories in Guipúzcoa, an innovator who was applying a series of design improvements ranging from introducing the dead rising to adopting the flat equal to half a breadth. His way of doing things was set out by his contemporaries as the *nueva fábrica de Juan de Veas* (Cano 1611, p. 17, 49, 51) and his influence on the drafting of the new *ordenanzas* was decisive.

In 1607, there was an increase in length in relation to the maximum breadth. It was achieved by lengthening the keel, while maintaining the same overhang. In 1613, the length was reduced by reducing the keel and the overhang. In 1618, the length was again reduced by shortening the keel and the overhang.

We point out other important aspects of these *ordenanzas* related to the design and that include similar characteristics to Sagri's *nave*: They introduce the dead rising; they limit the depth on the deck to half a breadth. It should be taken into account that the *As-Dos-Tres* rule prevailing in the Bay of Biscay did not establish a limit for the depth. With regard to the depth at the maximum breadth, it remains the same as the depth at the deck, except in 1618 when it descended by half a *codo*. Other characteristics that have a notable difference from Sagri's *nave* are: The flat established at half breadth. A final aspect to be noted is that these Ordinances limit the number of decks to only two. The decks that in the sixteenth century went further below the waterline were replaced by 'naked' beams.

3 Tonnage Formulas as an Architectural Index in the Light of Nicolò Sagri's Manuscript

3.1 Generalities

Sagri devotes the entire Chap. 7 of his manuscript *Il Carteggiatore* to tonnage determination, explaining three formulas with different measure units. The aim of this study is to compare them with those used for Genoese, Portuguese, and Biscayne ships that – according to Sagri – had the same proportions of Ragusan ships. Before examining them, it is good to resume a few concepts about tonnage, a complex subject concerning sometimes volume, sometimes weight.

3.1.1 Tonnage as Volume: Gross and Net Tonnage

Gross and net tonnage (*Sp.: tonelaje o arqueo bruto/neto Fr.: tonnage ou jauge brute/nette, It.: stazza lorda/netta*) until a recent past were the sum, respectively, of all the enclosed volumes of a ship and of all the volumes were cargo could be stored. In early modern times, net tonnage was measured in different units according to the Country and the transported merchandise. Dry goods were bagged in sacks that could be stored leaving no empty space, so at full load their volume equalled the volume of the hold. For liquids it was different. They were transported in casks, called tuns (*toneles* in Portuguese and Spanish, *tonneaux* in French, *botti* in Italian) which left some empty space between them and among the ship timbers when stored in hold. The volume occupied was much more than the contained one and the measure unit used for net tonnage had to take account of the proportion between the two. Gross tonnage during the sixteenth century was not generally taken into account. In Spain only it was possible to find something similar to this concept, estimated through a percentage (20–25%) to add to net tonnage. It was expressed in *toneladas de sueldo,* and it took account of the volumes of dead works, i.e. between the second and the upper deck and inside the quarter-deck, as it is stated in a document of 1593.[26] In Great Britain, gross and net tonnage were later measured using an imperial unit, the ton burden or register ton of 100 cubic feet (2.83 m^3). In a recent past they became of worldwide use, and they were called gross register and net register tonnage. Since 1969 they are dimensionless indexes resulting from

[26] 'Relación de la fábrica de doce galeones de guerra de la Escuadra Yllirica de Pedro de Ivella y Estéfano Dolisti. Carta de Pedro de Ivella al rey, de 17 diciembre 1593.' AGS, Guerra Antigua, Leg. 380–105, f°27.

complex mathematical formulas expressing the size, respectively, of a ship and her hold. Net tonnage of early modern ships is today more conveniently studied converting the original measure units into cubic metres.

3.1.2 Tonnage as Weight: Displacements Tonnage and Deadweight Tonnage

According to the Archimedes' principle, the weight of a ship equals the weight of the water she displaces, called displacement. It can be considered at different load conditions, the extremes being at full load and at ship unloaded, respectively, called full load displacement (*Sp.*: *desplazamiento máximo, Fr.: déplacement à pleine charge, It.: dislocamento a pieno carico*) and light displacement *(Sp.: desplazamiento en rosca, Fr.: déplacement lège*, *It.: dislocamento leggero*). The difference between them is called deadweight, and it can be considered with reference to the weight of the cargo only (net deadweight, *Sp.: porte neto*, *Fr.: port net, It.: portata netta*) or also to ballast, crew, passengers if any, provisions and ordnance (gross deadweight, *Sp.: porte bruto, Fr.: port en lourd, It.: portata lorda*). The maximum weight that a ship could carry was determined not only by the volume of her hold, but most of all by the limit to which her hull could be immersed to navigate safely (waterline). A cargo consisting only of high density materials would result in a hold with plenty of empty space while the ship had reached her highest waterline. If charged in proportion to its volume, such a cargo would provide little earning to ship's owners. Conversely, a cargo consisting only of low density materials would give little profit if charged by weight. The most profitable was to charge 'light' goods by volume and 'heavy' goods by weight. Of course there was a relation between the two physical quantities, and in the sixteenth century in Genoa it was considered 4 *cantari/salma*, corresponding to 0.72 t/m^3 (see paragraph 7.3.5). Historical sources give no elements on the displacement of Renaissance ships, and very little of those of the seventeenth century. According to Fournier's *Hydrographie* of 1643 and to the Dutch Witsen that in 1671 quoted him, a ship could carry as much cargo as her own weight: in today's terms, her net deadweight was equal to her light displacement (Fournier 1643, p. 780; Hoving et al. 2012, p. 20). To obtain full load displacement, the weight of ballast, crew, passengers if any, provisions and ordnance must be added to net deadweight and light displacement. In this study, the term 'tonnage' has been used only with general reference, including both volume and weight; otherwise, it has been specified whether net/gross tonnage or net/gross deadweight is concerned.

3.1.3 Block Coefficient and Its Relation with Ship Proportions

The proportion between the volume of the immersed hull (or the displaced water) and the volume of the parallelepiped circumscribed to it, is called block coefficient. It is a dimensionless quantity expressing the fullness of forms: the higher the block coefficient, the bulkier the hull. It is important to remark that ships with the same proportions can have different block coefficients: the bulkier keeping her main cross-section almost unvaried in a long, central part of the hull, then tapering near stern and bow (high block coefficient), the slimmer immediately tapering from the main cross-section towards the extremities (low block coefficient). For this reason, it is an important architectural index to be studied together with ship proportions.

3.1.4 Formulas, Method of Study and 'Block Coefficient of the Hold'

Since the Renaissance, instructions to determine tonnage were given in plain words, then giving a practical example; expressing them in formulas is a more recent habit. It is important to remark that, when net tonnage was considered, dimensions and volume were never expressed in the same units, like *piè* and cubic *piè*, so formulas included, in a more or less evident way, a measure conversion factor. When the result was net deadweight as in the case of some Genoese ships, a 'weight to volume' coefficient too had to be present. To date formulas have been studied solving all the operations described, which is correct from a mathematical point of view, but it does not help in comparing them. In this chapter, with reference to experimental sciences, formulas are written including measure units of both dimensions and coefficients, in order to verify their coherence and to make evident whether they are about volume or weight. In order to make a comparison, it is necessary to eliminate all the conversion factors by transforming all measures in the same units, such as metres and cubic metres. When deadweight is concerned, early modern weight units are converted into (metric) tons of 1000 kg. Most of the studied formulas, like Sagri's ones, can be reduced to a form in which net tonnage (NT) equals the product of the ship's principal dimensions (Length of hold by maximum Breadth by Depth of hold) multiplied by a coefficient:

$$\mathrm{NT} = \mathrm{L} \cdot \mathrm{B} \cdot \mathrm{D} \cdot \mathrm{c}.$$

Generally, measures are taken at the height of the widest point of the hull (maximum breadth), coinciding with the waterline at full load. This coefficient can be expressed as the net tonnage (the volume of the hold) divided by the volume of the parallelepiped circumscribed to it. It is similar to the above-mentioned block coefficient of the ship, but it is referred to her interior volume, and since now I will call it 'block coefficient of hold' (bch):

$$\underline{\mathrm{bch} = \mathrm{NT} / \left(\mathrm{L} \cdot \mathrm{B} \cdot \mathrm{D}\right)}$$

The former is measured outside the hull up to the waterline at full load, the latter inside the hull to an upper limit that generally coincided with maximum breadth/waterline. The difference between the two is mainly due to the thickness of the hull. Though not being identical, both the coefficients can be considered indicative for the fullness of forms of ships.

3.1.5 The 5% Reduction, or 0.95 Factor

In three out of the six examined formulas for net tonnage is present a reduction of 5%, that can be expressed as a 0.95 factor. The first to write of it was the Spanish Busturia in 1568, followed by Sagri in 1571. In Spain the last were Thomé Cano in 1611 and the *Ordenanzas* of 1613 and 1618. In Eastern Mediterranean the Ragusan Ohmucevic was the last circa 1661, stating that with the new formulas it was not necessary any more. Spanish authors explained it with the necessity of taking account of the taper of the hull towards stern and bow and to the room occupied by well pumps; nevertheless the mentioned *Ordenanzas* gave no explanation for it. Sagri was the author who more detailed it, considering a reduction from 3% to 10% according to the presence of partitions inside the hold and to a more or less flat bottom in the hull. In his opinion, a 5% reduction was appropriate for most ships. Crescentio and Ohmucevic referred to the same 5% reduction due to the above-mentioned partitions (Crescentio 1602, pp. 69–70).

3.2 Sagri's Formulas for Net Tonnage

In Chap. 7 of his manuscript, Sagri exposes three formulas to determine net tonnage (that he calls *portata*), adapted to different measure units: for length *piedi* (or *piè*) of Venice and *chobitti* (allegedly common in Western Mediterranean), for volume *carri* of Naples and *salme generali* of Sicily, both common in Italy and Dalmatia. Sagri's formulas only deal with volume; no reference is made to the weight that a ship could carry. Ships were measured at the widest point of the hull, coinciding with the waterline at full load, the height of the second deck (out of three), the top of the hold, and also the highest level of the cargo when it consisted in wheat only. The dimensions considered by Sagri were: length (L) at the second deck, maximum breadth (B), and depth of hold (D), the latter measured from the upper face of the keel (f°16 V–20 V). Sagri's formula can be reduced to the product of the three principal dimensions of the ship multiplied by a factor that, after converting all measures into a single unit, is the block coefficient of the hold (bch):

$$NT = L \cdot B \cdot D \cdot c$$
$$c = NT / \left(L \cdot B \cdot D\right) = bch$$

The reference merchandise were grains (usually wheat) bagged in sacks that could be stored leaving no empty space, so there was no need to take account of the difference between the volume contained and the space occupied by containers, as it was for casks and barrels. In this case the transported volume coincided with the volume of the hold.

3.2.1 Sagri's First Formula for Net Tonnage (*Piedi* to *Salme*)

Net tonnage, expressed in *salme generali di Sicilia* (sgS), results from the product of the three main dimensions of the ship expressed in *piedi di Venezia* (pV, Venetian feet of 0.3477 m), then subtracting one third from the result (i.e. multiplying by two thirds), subtracting again 5% of the new result (i.e. multiplying by 0.95), and finally dividing by ten:

$$NT_{[sgS]} = \left[\left(L_{[pV]} \cdot B_{[pV]} \cdot D_{[pV]} \cdot 2/3 \right) - 5\% \right] / 10_{[sgS/pV^3]} = L_{[pV]} \cdot B_{[pV]} \cdot D_{[pV]} \cdot 0.0633_{[sgS/pV^3]}$$

Converting into metres, according to early modern equivalence 1 *carro* = 7 *salme* (1 *salma* = 0.2845 m^3), the block coefficient of hold is 0.429:

$$NT_{[m^3]} = L_{[m]} \cdot B_{[E]} \cdot D_{[m]} \cdot 0.0633_{[sgS/pV^3]} \cdot 0.2845_{[m^3/sgS]} / 0.3477^3_{[m^3/pV^3]} =$$

$$= L_{[m]} \cdot B_{[m]} \cdot D_{[m]} \cdot 0.429$$

$$bch = NT_{[m^3]} / \left(L_{[m]} \cdot B_{[m]} \cdot D_{[m]} \right) = 0.429$$

Today's metrology has established the equivalence 1 *carro* = 7.5 *salme* (1 *salma* = 0.2655 m^3) (DELL'OSA, 2010, 7), in this way the block coefficient of the hold becomes 0.400:

$$NT_{[m^3]} = L_{[m]} \cdot B_{[m]} \cdot D_{[m]} \cdot 0.0633_{[sgS/pV^3]} \cdot 0.2655_{[m^3/sgS]} / 0.3477^3_{[m^3/pV^3]} =$$

$$= L_{[m]} \cdot B_{[m]} \cdot D_{[m]} \cdot 0.400$$

$$bch = NT_{[m^3]} / \left(L_{[m]} \cdot B_{[m]} \cdot D_{[m]} \right) = 0.400$$

3.2.2 Sagri's Second Formula for Net Tonnage (*Piedi* to *Carri*)

Net tonnage, expressed in *carri di Napoli* (cN) of 1.9915 m^3, results from the product of the three principal dimensions of the ship expressed in *piedi di Venezia* (pV), then subtracting 10% (i.e. multiplying by 0.9) and dividing by 100:

$$NT_{[cN]} = L_{[pV]} \cdot B_{[pV]} \cdot D_{[pV]} \cdot 0.9 / 100_{[cN/pV^3]} = L_{[pV]} \cdot B_{[pV]} \cdot D_{[pV]} \cdot 0.009_{[cN/pV^3]}$$

Converting the formula into metres, the block coefficient of the hold is 0.426.

$$NT_{[m^3]} = L_{[m]} \cdot B_{[m]} \cdot D_{[m]} \cdot 0.009_{[cN/pV^3]} \cdot 1.9915_{[m^3/cN]} / 0.3477^3{}_{[m^3/pV^3]} = \\ = L_{[m]} \cdot B_{[m]} \cdot D_{[m]} \cdot 0.426$$

$$bch = NT_{[m^3]} / \left(L_{[m]} \cdot B_{[m]} \cdot D_{[m]} \right) = 0.426$$

3.2.3 Sagri's Third Formula for Net Tonnage (*Chobitti* to *Salme*)

Sagri states that the last formula considers the units used to measure ships outside of Venice, in Western Mediterranean, Italy, and Spain: the *chobitti* (cbt) of three *palmi di canna* each. Net tonnage, expressed in *salme generali di Sicilia* (sgS), results from the product of the three principal dimensions of the ship, subtracting one fourth (i.e. multiplying by three fourth, or 0.75) then subtracting again 5%:

$$NT_{[sgS]} = L_{[cbt]} \cdot B_{[cbt]} \cdot D_{[cbt]} \cdot 0,75_{[sgS/cbt^3]} \cdot 0.95 = L_{[cbt]} \cdot B_{[cbt]} \cdot D_{[cbt]} \cdot \\ 0.7125_{[sgS/cbt^3]}$$

Converting the formula into metres, according to the early modern equivalence 1 *carro* = 7 *salme* (1 *salma* = 0.2845 m^3), and to the one stated by Sagri 1 *chobitto* = 2.25 *piedi di Venezia* (= 0.7823 m), the block coefficient of hold becomes 0.423:

$$NT_{[m^3]} = L_{[m]} \cdot B_{[m]} \cdot D_{[m]} \cdot 0.7125_{[sgS/cbt^3]} \cdot 0.2845_{[m^3/sgS]} / 0.7823^3{}_{[m^3/cbt^3]} = \\ = L_{[m]} \cdot B_{[m]} \cdot D_{[m]} \cdot 0.423$$

$$bch = NT_{[m^3]} / \left(L_{[m]} \cdot B_{[m]} \cdot D_{[m]} \right) = 0.423$$

Today's metrology has determined the correct equivalences: 1 *carro* = 7.5 *salme* (1 *salma* = 0.2655 m^3) and 1 *chobitto* = 0.7432 m (DELL'OSA 2010, 7).

$$NT_{[m^3]} = L_{[m]} \cdot B_{[m]} \cdot D_{[m]} \cdot 0.7125_{[slm/cbt^3]} \cdot 0.2655_{[m^3/slm]} / 0.7432^3{}_{[m^3/cbt^3]} = \\ = L_{[m]} \cdot B_{[m]} \cdot D_{[m]} \cdot 0.461$$

$$bch = NT_{[m^3]} / \left(L_{[m]} \cdot B_{[m]} \cdot D_{[m]} \right) = 0.461$$

Due to inaccuracy of early modern conversion factors, the block coefficient of the hold obtained with Sagri's third formula (0.423) was 9% smaller than the correct one (0.461).

3.2.4 The Application of Sagri's Formulas

Sagri provides an example of the application of each formula to a ship of 90 x 30 x 15 *piedi di Venezia* (31.3 × 10.4 × 5.2 m, length x breadth x depth of hold), or 40 x $13^1/_3$ x $6^2/_3$ *chobitti*, stating the equivalence he gives 1 *chobitto* = 2.25 *piedi*. He gives the resulting net tonnage of the three formulas: respectively 2565, 2548 and 2534 *salme* (the second one converted from *carri*). According to Sagri, these differences were irrelevant compared to such huge quantities, the results of the first and third formulas being +0.7% and − 0.5% of the second one. The three block coefficients of hold, considering the equivalences proposed by Sagri, fall very near: 0.429, 0.426, and 0.423 (average 0.426). Actually, once corrected according to today's metrology, the first and third formulas are more divergent: 0.400 and 0.461, with a difference of −7% and + 9% compared to average 0.429. The block coefficient of hold resulting from the second formula (0.426, like the average of the original coefficients) is the only one not to be affected by the inaccuracy of the equivalences and is also almost identical to the average of the corrected ones.

3.2.5 The Survival of Sagri's Third Formula in the Seventeenth Century

Bartolomeo Crescentio, a Roman engineer, published in 1602 a treatise entitled *Della nautica mediterranea*, often quoting the manuscript *Il Carteggiatore*, and exposing Sagri's first formula with the same example of a *nave* of 90 × 30 × 15 *passi* and the same equivalence of 1 *carro* = 7 *salme*, instead of 7.5 as established by today's metrology (Crescentio 1602, pp. 69–70). Circa 1661, 90 years after the death of Nicolò Sagri, the Ragusan mathematician Petar Damjan Ohmucevic wrote a manuscript dealing with fractions and extraction of second and third roots, with a method to calculate ships' tonnage. An excerpt of it, with the title '*Del modo di mesurare, o archiare le navi di qualsivoglia genere e forma, e riduli con detto archiamento alla giusta portata di tanti carra di tomola trentasei l'uno'*.[27] is conserved in the Dubrovnik Historical Archives. Before explaining his own original method to determine ships' tonnage, forerunning the application of integral calculus, he described Sagri's first formula as the most used of his time. He gave the same example of a ship 90 × 30 × 15 *piedi di Venezia*, expressing net tonnage in *salme generali di Sicilia,* then converting it to *carri di Napoli*, according to the same factor 1 *carro* = 7 *salme.* Ohmucevic added that this formula was widely used in the Mediterranean area, from the Levant to Barcelona, through Venice and the entire

[27] I am grateful to Divo Basic for communicating me the transcription of this document.

Adriatic coast. In his opinion, this method had worked well until ships had been built in the old way, but at his time their design had changed too much and the use of that formula resulted too far away from reality (Sisevic 1952). An incoherence exists: Ohmucevic stated that the formula he described, the same as Sagri's first one, made for Venetian *passi*, was used throughout almost the whole Mediterranean area, including Venice and the Adriatic Sea; Sagri explained that in his third formula measures were expressed in *gobiti*, a unit that – according to his statement – was used outside of Venice, being common in the Western Mediterranean, in particular Spain and Italy.

3.3 Tonnage Determination in Spain in the Sixteenth Century

During the sixteenth century in Spain ships' dimensions were expressed using two different units, the *codo castellano* of 0.557 and the *codo de ribera* of 0.575 m. Net tonnage was measured as the number of casks called *pipas andaluzas* or *de Sevilla* that a ship could carry. The space occupied by two *pipas* was a *tonel* of eight cubic *codos*, but it had two different estimates: the *tonel castellano* or *tonelada de carga* was eight cubic *codos castellanos*, corresponding to 1.382 m^3, the *tonel macho* was eight cubic *codos de ribera*, or 1.521 m^3. In Northern Spain the *codo de ribera* was used, while in Andalusia both the *codos* were used, with a prevalence of the *castellano.*

3.3.1 Tonnage Determination in Spain in the First Half of Sixteenth Century

Since the late fifteenth throughout the first half of the following century in Spain is documented an empirical method to determine net tonnage, based on the use of hoops and gauges to estimate how many casks could be contained inside the hold. A professional figure existed, the *arqueador*, an officer charged to determine tonnage. It is believed that mathematical formulas based on ship's dimensions existed together with empirical methods, becoming of general use before the mid-sixteenth century (Casado Soto 1988, pp. 73–77). Evidence for this assessment is not strong, as it is possible to verify in the following examples. The net tonnage of a *nao* named '*Trinidad*', property of Ochoa Sáez de Goronda from Bilbao, examined in 1523 in Portugalete by the inspector Juan Nicolás de Areita was declared 190 unspecified *toneles,* but the method used is unknown. The ship had the following dimensions (in unspecified *codos*): length of the hold 41¼, keel 30, maximum breadth 13, depth of hold 6 (Guiard y Larrauri and Basas Fernández 1968, p. 76). Applying Spanish tonnage formulas of the sixteenth century, the best result is given by the Busturia's (1568) and Barros' (1580) one, at 191 *toneles* (Hormaechea et al. 2018, pp. 162–168). Probably this is the reason why it has been recently assumed that the Busturia's and Barros' formula was already used in 1523 (Castro 2013, p. 1139; Casabán et al.

2014, p. 570). Nevertheless, there is no evidence allowing to exclude that Arteita had used an empirical approach converging to the same result of the later formulas. Another document written in Sevilla in 1552 refers of the tonnage determination of four Spanish ships, whose capacity was defined by the number of small casks (*pipas*) that could be contained in different parts of the hold, the result divided by two to obtain the number of *toneles machos* of 1.521 m^3 (considering a *tonel* the volume occupied by two *pipas*), then 20–25% was added to obtain the *toneladas de sueldo*. The use of *toneles machos* in Andalusia contradicts the current belief that in that region only *toneles castellanos*, i.e. *toneladas de carga* of 1.382 m^3 were used. The four ships were loaned by the Crown for the *armada* and had no cargo, so *pipas* could not have been counted after they had been loaded, and for this reason it has been considered that a mathematical method had to be used (Casado Soto 1988, pp. 78–80, 261). Actually using hoops and gauges it was possible to estimate the amount of *pipas* that could have been contained in each part of the hold and in this case too there is no sure evidence that a mathematical method had been used. The three earliest Spanish tonnage formulas known are almost coeval, dating to the years 1560–1575, and probably they were in use at the same time.

3.3.2 The Presidente-Visitador's Formula (c.1560–1570)

This formula is known through an undated Spanish document written by a *visitador*, an officer of the *Casa de la Contratación* charged to inspect ships. Casado Soto (1988), the first who published it, attributed it to the 60s of the sixteenth century in his text, but he wrote c.1560 in a caption as well as in the appendix, and only the latter date was reported by the authors that dealt with this subject after him. The document contained no geographical indication about where it had been written. Ship's measurements were given in *codos mayores* (*codos de ribera* de 33 dedos), and tonnage in unspecified *toneles* (to be intended as *machos*, since the kind of *codos*), with the approximated equivalent *toneladas de sueldo* (Casado Soto 1988, pp. 90, 82, 265–270). Some later authors have inexplicably reported that the Presidente-Visitador's formula was used in the region of Cadiz-Sevilla and that measurements were given in *codos castellanos* and *toneladas de carga* (Castro 2013, p. 1139; Casabán et al. 2014, p. 570). Besides describing the formula, the document gives dimensions and net tonnage of some ships. The first one is a 300 *toneles nao* built to serve in the *armada* as a coast guard. Her keel is 32 *codos*, the length of the hold 48 or 49, the maximum breadth 15, the depth of hold 7.5, and the upper deck 3.5 *codos* higher. The last ship is a smaller one of unspecified use, and is given as an example of the calculations of the tonnage formula. Her keel is 20 *codos*, the length of her hold is not given, her maximum breadth 10 *codos*, her depth of hold 8 *codos* (Hormaechea et al. 2018, p. 163). According to the Presidente-Visitador, net tonnage was the result of the product of the length of the keel, the maximum breadth and the depth of hold, multiplied by two thirds:

$$NT_{[cdr^3]} = K_{[cdr]} \cdot B_{[cdr]} \cdot D_{[cdr]} \cdot 2/3 = K_{[cdr]} \cdot B_{[cdr]} \cdot D_{[cdr]} \cdot 0.667$$

The conversion into metres by multiplying every dimension by the factor 0.575 m/cdr, produce no changes in the formula, as only one measure unit was present:

$$NT_{[m^3]} = K_{[m]} \cdot B_{[m]} \cdot D_{[m]} \cdot 2/3 = K_{[m]} \cdot B_{[m]} \cdot D_{[m]} \cdot 0.667$$

Inserting the measures of the first ship mentioned in the document, the right tonnage of 300 *toneles* can be obtained considering the depth of hold equivalent to half the beam, then dividing by eight. Substituting the ratio 'keel to length' (2/3, or 0.666) of the first ship taken as an example by the Presidente-Visitador, into his own formula, the resulting block coefficient of hold is 0.444:

$$NT_{[m^3]} = 2/3\,L_{[m]} \cdot B_{[m]} \cdot D_{[m]} \cdot 2/3 = L_{[m]} \cdot B_{[m]} \cdot D_{[m]} \cdot 0.444$$

$$bch = NT_{[m^3]} / \left(L_{[m]} \cdot B_{[m]} \cdot D_{[m]}\right) = 0.444$$

It is possible to apply this formula to a ship with the proportions of the *nave* described by Sagri, where K = $1+{}^{15}/_{16}$ B, (obtained by subtracting the overhangs from the length), and B = 1/3 L, so K = 31/48 L. By substituting this equivalence into the Presidente-Visitador's formula, the block coefficient of hold becomes 0.431:

$$NT_{[m^3]} = 1^{15}/_{16}\,/3\,L_{[m]} \cdot B_{[m]} \cdot D_{[m]} \cdot 2/3 = L_{[m]} \cdot B_{[m]} \cdot D_{[m]} \cdot 0.431$$

$$bch = NT_{[m^3]} / \left(L_{[m]} \cdot B_{[m]} \cdot D_{[m]}\right) = 0.431$$

only 1% and 0.5% more than the average of Sagri's coefficients, 0.426 and 0.429, respectively, before and after correcting the equivalence *carri* to *salme*.

3.3.3 Captain Rodrigo Vargas' Formula (c.1565–1575)

Captain Rodrigo Vargas worked as *arqueador* in Sanlúcar, at the mouth of river Guadalquivír in Atlantic Andalucía, in the period 1565–1575. According to the formula he used, net tonnage was calculated by multiplying the length of the hold by the squared semi-sum of depth of hold and half the breadth, the result divided by eight to obtain *toneles machos* from cubic *codos* (to be intended as *de ribera*, since the use of *toneles machos*). While the published document openly mentions *toneles machos*, it has sometimes been reported as mentioning *codos castellanos* and *toneladas de carga* (Casabán et al. 2014, p. 570). Depth of hold seems to be measured at the second deck (out of three), situated half a *codo* or one *codo* higher than half the maximum breadth in the examples given by Vargas: 8 *codos* for a breadth of 15, or 9 *codos* for a breadth of 16 (Casado Soto 1988, pp. 81–84, 271–274):

$$NT_{[tnlM]} = L_{[cdr]} \cdot \left[\left(B_{[cdr]} / 2 + D_{[cdr]}\right) / 2\right]^2 / 8_{[cdr^3/tnlM]}$$

Converting to metric decimal units:

$$NT_{[m^3]} = L_{[m]} \cdot \left[\left(B_{[m]} / 2 + D_{[m]}\right) / 2\right]^2$$

If we substitute in Vargas' formula the proportion between depth of hold and maximum breadth of the first ship he gives as example, i.e. D = 8/15 B.

$$NT = L \cdot \left[\left(B / 2 + 8 / 15B\right) / 2\right]^2 = L \cdot \left(31 / 30B\right)^2 / 4 = L \cdot 961 / 900B^2 / 4 = L \cdot B^2 \cdot 0.267$$

Then, substituting the reversed proportion B = 15/8 D the resulting block coefficient of hold is 0.501:

$$NT = L \cdot B \cdot \left(15 / 8D\right) \cdot 0.267 = L \cdot B \cdot D \cdot 0.501$$

$$bch = NT_{[m^3]} / \left(L_{[m]} \cdot B_{[m]} \cdot D_{[m]}\right) = 0.501$$

Using the proportion of the second ship mentioned by Vargas (D = 9/16 B), the block coefficient of hold would be 0.502.

For ships whose depth of hold equals half the maximum breadth (D = B/2), like those described by Sagri, the formula becomes:

$$NT_{[m^3]} = L_{[m]} \cdot \left[\left(B_{[m]} / 2 + B_{[m]} / 2\right) / 2\right]^2 = L_{[m]} \cdot B^2_{[m^2]} / 4$$

and, after substituting the reversed proportion B = 2 D, the block coefficient of hold becomes 0.500:

$$NT_{[m^3]} = L_{[m]} \cdot B_{[m]} \cdot 2D_{[m]} / 4 = L_{[m]} \cdot B_{[m]} \cdot D_{[m]} / 2 = L_{[m]} \cdot B_{[m]} \cdot D_{[m]} \cdot 0.500$$

In the three examined cases the coefficients of Vargas' formula diverge very little, just 0.2% from the average 0.501. Ships with a depth of hold D = 5/8 or 3/4 of the maximum breadth (like a depth of hold of 10 or 12 *codos* instead of 9 as in Vargas' example, for a breadth of 16 *codos*) would have a higher coefficient of respectively 1.25% or 4%. The complexity of Vargas' formula gives relevant differences only when the depth of hold is three quarters of the breadth or more, otherwise the results are very similar to those of the simple product of the three dimensions divided by two.

3.3.4 The Busturia's and Barros' Formula (Busturia, 1568; Barros, 1580; Real Cédula, 1590)

Domingo de Busturia was the first to differentiate the tonnage of warships and merchantmen, and the latter between old and new design (*arte vieja* and *arte nueva*). He explained where measurements had to be taken: the breadth at the widest point, the depth from the maximum breadth to the floor (*soler*, not to the flat of the floor, or *plan*), the length over the first deck. Net tonnage is the result of the sum of half the breadth plus the depth of hold, divided by two and raised to the square, then multiplied by the length of hold, and finally multiplied by 0.95 and divided by 8, the conversion factor from *codos de ribeira* to *toneles machos*, the units in which measurements are expressed (Hormaechea et al. 2018, pp. 164–165):

$$NT_{[tnlM]} = L_{[cdr]} \cdot \left[\left(B_{[cdr]} / 2 + D_{[cdr]} \right) / 2 \right]^2 \cdot 0.95 / 8_{[cdr^3/tnlM]}$$

Cristobal de Barros, an *arqueador* working in Cantabria, in Northern Spain, since 1563, wrote a document in 1580 describing the method he used to determine tonnage, the same as Busturia's. He also explained the way to take measurements, adding that the length had to be taken at the same height where maximum breadth and depth of hold were taken (Casado Soto 1988, pp. 84–88, 287–291). The same situation described by Sagri, as we have seen, that corresponds also to waterline. By da en san Lorenzo el 20 de agosto de 1590. M.N.M. Collecion Navarrette, N° de catalogo 789 of 1590, the use of this formula, together with the measure units concerned (the *codos de ribera* of 33 *dedos* and the *tonel macho* of 8 cubic *codos de ribera*) were imposed to the whole Spain. The use of this formula survived little beyond the end of the sixteenth century, being considered in the *Reales Ordenanzas* of 1607 and 1618. The formula was the same as Vargas', with just the adding of a reduction of 5%, the above-mentioned 0.95 coefficient (Casado Soto 1988, pp. 289–291; Hormaechea et al. 2018, p. 169). The block coefficients of the hold became 0.476 and 0.477 in the two Vargas' examples (D = 5/8 B and D = 9/16 B), and 0.475 when D = 1/2 B; in other words 0.476 ± 0,2%. Relevant differences seem to exist only for ships with particularly deep or shallow drafts, as it has been already commented about Vargas' formula.

3.4 Tonnage in Portugal in the Sixteenth Century

During the sixteenth century in Portugal tonnage was determined in the traditional empiric way using hoops and gauges. In his manuscript *Ars Nautica* of circa 1570, Fernando Oliveira explained a method consisting in the sum of the *tonéis* that could be stored in each *rumo* of length of the keel. The *rumo* was a measure unit equivalent to 1.54 m, corresponding to the major dimension of a *tonel*, so the method he was describing could be the 'hoops and gauges' one. In his later manuscript *Livro da fabrica as naus* of circa 1580, Oliveira explained that a *nau* with an 18 *rumos* keel could store 64 *tonéis* in her main cross-section, but this capacity was decreasing in the other *rumos* of the keel length, because of the rising and the narrowing of the hull. According to him, instead of the 'over 1000 *tonéis*' resulting from the multiplication of the 64 by the 18 that could be stored in the keel length, the ship could carry no more than 600. Oliveira did not propose any mathematical solution to this problem (Castro 2013, p. 1138). No formula is known to have been used throughout the sixteenth century to at least 1612, when a Spanish document referred that the 'hoops and gauges' empirical method was still in use in Portugal. Nevertheless shipwrights were aware of the relation between ship dimensions and net tonnage, and tables existed relating the latter to the length of the keel. F. Contente Domingues proposed a formula explaining the relation between net tonnage and keel length, which does not imply that it was known and used in the sixteenth century. It considers the length of the Keel in *rumos* (rm), the maximum Breadth and the Depth of hold in *palmos de goa* (pdg), and the resulting net tonnage in Portuguese *toneladas* (Hormaechea et al. 2018, p. 184):

$$NT_{[tnldP]} = K_{[rm]} \cdot B_{[pdg]} \cdot D_{[pdg]} / 20_{[rm \cdot pdg^2/tnldP]} = K_{[rm]} \bullet B_{[pdg]} \cdot D_{[pdg]} \cdot 0.05_{[tnldP/rm/pdg^2]}$$

or, converting the measure of the keel from *rumos* into *palmos de goa*:

$$NT_{[tnldP]} = K_{[pdg]} \cdot B_{[pdg]} \cdot D_{[pdg]} / 120_{[pdg^3/tnldP]} = K_{[pdg]} \cdot B_{[pdg]} \cdot D_{[pdg]} \cdot 0.008(3)_{[tnldP/pdg^3]}$$

The vertical dimension used in Portugal to determine tonnage in the sixteenth century was measured up to the first deck instead of the level of maximum breadth/waterline, and there was no fixed proportion between the two heights (Hormaechea et al. 2018, p. 185). For these reasons, it is not possible to convert the formula proposed by F. Contente Domingues to the height of maximum breadth/waterline to study the block coefficient of hold in a general way.

3.5 Tonnage in Genoa in the Sixteenth Century

No nautical treatise has been left by Genoese seamen or shipwrights, possibly in an attempt to preserve secrecy. Alternatives sources for Genoese shipbuilding are notarial records, as sometimes they mention data about ships' dimensions and tonnage. Many construction contracts of Genoese ships have been published, in which tonnage was measured sometimes as a weight expressed in *cantari* of Genoa (cG), sometimes as a volume expressed in *mine* or in *salme generali* of Sicily (sgS). The equivalence was 1 *salma* = 2.5 *mine* before 1550, and 2.37 *mine* after that date. The tonnage of a same ship could be expressed as net tonnage in *salme* in some document and as net deadweight in *cantari* in some other. A 'weight to volume' conversion coefficient existed, allowing to transform net tonnage into net deadweight, according to the formula $NT_{[sgS]} = NDW_{[cG]} / 4_{[cG/sgS]}$.[28] Converted into the metric system, the coefficient 4 *cantari/salma* corresponds to 0.72 t/m^3, very near to the average density of wheat, 0.75 t/m^3. Liquids carried on ships were measured in *botti:* their capacity is not known, but two equivalences existed, 10 *cantari/botte* and 0.4 *botti/salma* (Borghesi and Calegari 1970, pp. 101–102; Gatti 1975, pp. 35–36). Such a measure unit did not exist in Genoa, where the largest containers for liquids were the *barile* and *metreta*, which capacity grew continuously during the sixteenth century, never exceeding, respectively, 0.078 m^3 and 0.156 m^3 (ROCCA, 1871: 81–2). From the first mentioned equivalence it is evident that every *botte* weighed 10 *cantari* of Genoa, or 476.5 kg, and from the second that it corresponded to 2.5 *salme generali* of Sicily, or 0.664 m^3, a volume too large to match the above-mentioned weight. The only possibility is that such volume, instead of the capacity, was the space occupied in the hold that also included the empty room between *botti* and among ship's timbers. Considering that the weight of the wooden cask was around 8% of the contained liquid, the resulting capacity of the *botte* is 0.4412 m^3 (Lane 1992, pp. 246–247). This is by far smaller than both the one of Venice (c. 0.600 m^3) and the one of Naples (0.523.5 m^3), but equivalent to the *pipa andaluza* (0.4437 m^3), also with reference to the space occupied in the hold (0.664 m^3 for both). The container, as well as the measure unit, used on board Genoese ships and called *botte*, actually was the *pipa andaluza*, adding another element to the strong maritime relations between Genoa and Spain.

3.5.1 Tonnage Formulas of Today for Genoese Renaissance Ships

On the basis of some Genoese contracts of the very last years of the sixteenth to the mid-seventeenth century, mentioning ships' dimensions and net deadweight, the existence of an empiric formula had been deduced by Luciana Gatti twenty years ago. Such a relation does not necessarily imply that a mathematical method was

[28] By the end of the sixteenth century, for fiscal reasons this factor was officially changed to 5 *cantari/salma*, but for practical nautical use it remained unchanged.

used at the time in Genoa, even if it is not unlikely that it existed, since in Venice tonnage formula are documented since the end of the fourteenth century, as exposed in the anonymous manuscript '*Libro di navegar*'.[29] According to the formula proposed by Gatti, net deadweight (NDW) in *cantari* of Genoa (cG) resulted from the product of length, breadth, and depth of hold expressed in *palmi di canna* of 0.2477 m (pdc) divided by nine (Gatti 1999, p. 285):

$$NDW_{[cG]} = L_{[pdc]} \cdot B_{[pdc]} \cdot D_{[pdc]} / 9_{[pdc^3/cG]}$$

In order to compare it with Sagri's third formula, ship measures are converted into *goa* or *gobiti* (gbt) of three *palmi di canna* (pdc):

$$NDW_{[cG]} = L_{[gbt]} \cdot B_{[gbt]} \cdot D_{[gbt]} \cdot 27_{[pdc^3/gbt^3]} / 9_{[pdc^3/cG]} = L_{[gbt]} \cdot B_{[gbt]} \cdot D_{[gbt]} \cdot 3_{[cG/gbt^3]}$$

Transforming net deadweight into net tonnage ($NT_{[sgS]} = NDW_{[cG]} / 4_{[cG/sgS]}$):

$$NT_{[sgS]} = L_{[gbt]} \cdot B_{[gbt]} \cdot D_{[gbt]} \cdot 3_{[cG/gbt^3]} / 4_{[cG/sgS]} = L_{[gbt]} \cdot B_{[gbt]} \cdot D_{[gbt]} \cdot 0.75_{[sgS/gbt^3]}$$

Converting into metres, the resulting block coefficient of hold is 0.485:

$$NT_{[m^3]} = L_{[m]} \cdot B_{[m]} \cdot D_{[m]} \cdot 0.75_{[sgS/gbt^3]} \cdot 0.2655_{[m^3/sgS]} / 0.7432^3_{[m^3/gbt^3]} = \\ = L_{[m]} \cdot B_{[m]} \cdot D_{[m]} \cdot 0.485$$

$$bch = NT_{[m^3]} / \left(L_{[m]} \cdot B_{[m]} \cdot D_{[m]}\right) = 0.485$$

3.5.2 Two Genoese *navi* of the Sixteenth Century and Their Tonnage

Out of the many Genoese ships published, two *navi* of the sixteenth century are known with their dimensions and tonnage. The first one was a *nave* with a net tonnage of 2000 *salme* (531 m³), and a net deadweight of 8000 *cantari* (381 t), built in 1546 in Celle, near Genoa. Her name was '*Santa Maria*', also known as '*Bertorota*' after her owner. Her length '*de roda in roda*' was 37 *goa* (27.53 m), her keel 25 *goa* and 2 *palmi di canna* (19.10 m), her breadth 38 *palmi* (9.42 m), her depth of hold has been estimated to half the breadth, as it was usual in Genoese *navi* of the time, 19 *palmi* (4.71 m) in this case (Borghesi and Calegari 1970, pp. 101–102). Her proportions were (0.5): 1: 2.03: 2.92 (depth: breadth: keel: length). Compared to the Ragusan *nave* described by Sagri 25 years later, her 'keel to breadth' ratio was less

[29] 'Libro di navigar', Anonymous, end of the fourteenth century. Manuscript in Civic Library Angelo Mai (Bergamo, Italy), MA334 (Accession Number) ex Σ. VII. 29, f°18R.

than 5% larger and her 'length to breadth' ratio less than 3% smaller, with even smaller overhangs. It is possible to calculate the block coefficient of hold:

$$\mathrm{bch} = \mathrm{NT}_{[\mathrm{m}^3]} / \left(\mathrm{L}_{[\mathrm{m}]} \cdot \mathrm{B}_{[\mathrm{m}]} \cdot \mathrm{D}_{[\mathrm{m}]}\right) = 0.531_{[\mathrm{m}^3]} / \left(27.53_{[\mathrm{m}]} \cdot 9.42_{[\mathrm{m}]} \cdot 4.71_{[m]}\right) = 0.435$$

definitely nearer to the block coefficients of the hold in Sagri's formula than to the one of the formula proposed by Gatti. Converting all measures in *goa* or *gobbiti* (gbt) of three *palmi di canna* (pdc), then applying Sagri's third formula, the net tonnage overestimates 6% the declared tonnage:

$$\mathrm{NT}_{[\mathrm{sgS}]} = 37_{[\mathrm{gbt}]} \cdot 12.666_{[\mathrm{gbt}]} \cdot 6.333_{[\mathrm{gbt}} \cdot 0.7125_{[\mathrm{sgS/gbt}^3]} = 2115_{[\mathrm{sgS}]}$$

It is also possible to apply the formula proposed by Gatti after converting it to obtain net tonnage expressed in *salme generali* of Sicily (sgS)

$$\mathrm{NT}_{[\mathrm{sgS}]} = 37_{[\mathrm{gbt}]} \cdot 12.666_{[\mathrm{gbt}]} \cdot 6.333_{[\mathrm{gbt}]} \cdot 0.75_{[\mathrm{sgS/gbt}^3]} = 2226_{[\mathrm{sg}S]}$$

The result overestimates 11% the declared tonnage.

The second ship was a *nave* with net tonnage of 3000 *salme 'vel* circa*'* ('around' 797 m³), and net deadweight of 12,000 *cantari* (572 t), the '*Santa Maria in Betelen',* built in 1599 in Varazze, near Genoa. Her length *'de roda in roda'* was 42 *gobbiti* (31.22 m), her keel 30 *gobbiti* (22.30 m), her breadth 39 *palmi di canna* (9.66 m), first deck height 22 *palmi* (5.45 m), second deck height 8 *palmi* (1.98 m), measured from the first deck (Gatti 1999, pp. 287–289). The height of the first deck at 5.45 m strongly suggest the presence of a level of 'naked' beams under it to strengthen hull structure, like the *baos vacíos in Spanish ships.* 'First deck to maximum breadth' ratio was 0.56 and 'second deck total[30] height to maximum breadth' ratio 0.77, while in the *nave* described by Sagri the equivalents for second and third deck were 0.50 and 0.75. The first and the second deck of the Genoese vessel corresponded, respectively, to the second and the third one of the Ragusan ship, while 'naked' beams had to be present in the former at the height where the latter had the first deck. Her proportions were 0.56: 1: 2.31: 3.23 (depth: breadth: keel: length), definitely different from those of the *nave* described by Sagri almost 30 years before: her 'depth to breadth' ratio was 12% larger, 'keel to breadth' ratio 19% larger, and 'length to breadth' ratio 8% larger. It is possible to calculate the block coefficient of the hold:

$$\mathrm{bch} = \mathrm{NT}_{[\mathrm{m}^3]} / \left(\mathrm{L}_{[\mathrm{m}]} \cdot \mathrm{B}_{[\mathrm{m}]} \cdot \mathrm{D}_{[\mathrm{m}]}\right) = 796.5_{[\mathrm{m}^3]} / \left(31.22_{[\mathrm{m}]} \cdot 9.66_{[\mathrm{m}]} \cdot 5.45_{[\mathrm{m}]}\right) = 0.484$$

[30] Measured from the keel.

the same as the one of the formula proposed by Gatti, 13% higher than Sagri's average one (0.428), and 5% higher than the third one after correction according to modern metrology (0.461). Converting all measures in *goa* or *gobbiti* (gbt) of three *palmi di canna* (pdc), and then applying Sagri's third formula, the net tonnage results:

$$NT_{[sgS]} = 42_{[gbt]} \cdot 13_{[gbt]} \cdot 7.333_{[gbt]} \cdot 0.7125_{[sgS/gbt^3]} = 2853_{[sgS]}$$

underestimating by 5% the declared tonnage of 3000 *salme*.

Applying the formula proposed by Gatti, once converted to *salme*, net tonnage results:

$$NT_{[sgS]} = 42_{[gbt]} \cdot 13_{[gbt]} \cdot 7.333_{[gbt]} \cdot 0.750_{[sgS/gbt^3]} = 3003_{[sgS]}$$

with a relative error of 0.1% compared to the declared tonnage.

Sagri's third formula appears to have overestimated 6% the net tonnage of the Genoese ship of the mid-sixteenth century, and underestimated 5% the one of the end of the century. On the contrary, Gatti's formula for Genoese ships, giving accurate results by the end of the sixteenth century through the first half of the following, heavily overestimated (11%) net tonnage in the mid-sixteenth century. In this case, we propose the use of a coefficient dividing by ten—instead of nine— which would have been more accurate:

$$NDW_{[cG]} = L_{[pdc]} \cdot B_{[pcd]} \cdot D_{[pdc]} / 10_{[pdc^3/cG]}$$

Converting *palmi di canna* into *gobiti*, according to the equivalence $1_{[gbt]} = 3_{[pdc]}$

$$NDW_{[cG]} = L_{[gbt]} \cdot B_{[gbt]} \cdot D_{[gbt]} \cdot 27_{[pdc^3/gbt^3]} / 10_{[pdc^3/cG]} = L_{[gbt]} \cdot B_{[gbt]} \cdot D_{[gbt]} \cdot 2.7_{[cG/gbt^3]}$$

Transforming net deadweight into net tonnage, according to the formula

$$NT_{[sgS]} = NDW_{[cG]} / 4_{[cG/sgS]}$$

$$NT_{[sgS]} = L_{[gbt]} \cdot B_{[gbt]} \cdot D_{[gbt]} \cdot 2.7_{[cG/gbt^3]} / 4_{[cG/sgS]} = L_{[gbt]} \cdot B_{[gbt]} \cdot D_{[gbt]} \cdot 0.675_{[sgS/gbt^3]}$$

Converting into metres, the resulting block coefficient of hold is 0.437:

$$NT_{[m^3]} = L_{[m]} \cdot B_{[m]} \cdot D_{[m]} \cdot 0.675_{[sgS/gbt^3]} \cdot 0.2655_{[m^3/sgS]} / 0.7432^3_{[m^3/gbt^3]} =$$
$$= L_{[m]} \cdot B_{[m]} \cdot D_{[m]} \cdot 0.437$$

$$bch = NT_{[m^3]} / \left(L_{[m]} \cdot B_{[m]} \cdot D_{[m]}\right) = 0.437$$

With the latter formulas, the net deadweight and the net tonnage of the *nave Bertorota* of 1546 would be

$$NDW_{[cG]} = L_{[gbt]} \cdot B_{[gbt]} \cdot D_{[gbt]} \cdot 2.7_{[cG/gbt^3]} = 8013_{[cG]}$$
$$NT_{[sgS]} = 37_{[gbt]} \cdot 12.666_{[gbt]} \cdot 6.333_{[gbt]} \cdot 0.675_{[sgS/gbt^3]} = 2003_{[sgS]}$$

with a relative error of less than 0.2% compared to the declared 8000 *cantari* and 2000 *salme* of the Genoese ship.

3.6 Comparison

The block coefficient of a ship is the ratio between the volume of the immersed part of her hull and the volume of the parallelepiped circumscribed to it. As a ratio between volumes, it is a dimensionless quantity. A similar ratio can be obtained from the net tonnage of a specific ship and her main dimensions or with a more general meaning from the transformation of net tonnage formulas. The ratio obtained from the latter is slightly different from the block coefficient of the ship, because it considers the internal volume of the hold, instead of the external volume of the hull. For this reason, in this study it has been called the block coefficient of hold. When measurements are taken up to the waterline, as in the case of Sagri's formulas, the difference consists only in the thickness of the hull. Though this slight difference, both coefficients can be taken as an index of fullness of forms of the hull: the higher the coefficient the bulkier the ship. This fullness of form can be visually represented with how slowly the main cross-section decreases in dimensions from mid-ship towards stern and bow.

The Ragusan *navi* described by Sagri in 1570–1571 had a block coefficient of hold of 0.423, 0.426, and 0.429, according to the three different formulas he proposed; in other words 0.426 ± 0.7%. Due to a certain degree of inaccuracy in measure units conversion factors used in the sixteenth century, after the correction according to modern metrology, Sagri's coefficients become more diverging, 0.400, 0.426, and 0.460, or 0.430 ± 7%, with an average 0.429. Sagri considered the ideal proportions of *navi* 0.5:1:1.94:3 (depth of hold: breadth: keel: length, all measurements but keel taken at second deck, coinciding with waterline; keel length obtained subtracting the overhangs from the length). He also stated that at his time these proportions were rarely respected in Ragusan shipyards, and that they were still the rule in Biscay, Portugal, and Genoa. The block coefficient of hold of those ships, considered by Sagri to have the same proportions, have been studied and compared, trying to understand if they also had similar fullness of forms.

In Spain net tonnage was determined in the first half of the sixteenth century with the traditional 'hoops and gauges' empirical method, and the use of mathematical methods is documented with evidence since the 60s of that century. Initially a few different formulas were in use, with different references to the vertical dimension (depth of hold), and different measure units: the *tonel castellano* or *tonelada de carga* (equivalent to eight cubic *codos castellanos*) and the *tonel macho* (equivalent to eight cubic *codos de ribera*). They were two different estimates of the volume occupied by two small casks, the *pipas andaluzas* (i.e. *de Sevilla*). By the time Sagri was writing *Il Carteggiatore*, a formula for net tonnage appeared in Spain with increasing success. In its early version, the block coefficient of the hold was slightly over 0.500. A few years later, in an attempt to be more realistic, a 5% reduction was included to take account of the taper of the hull at bow and stern and of the space occupied by pump wells. After this correction the block coefficients reduced to 0.475. In 1590 the Crown imposed the use of this formula, as well as of the *codo de ribera* and *tonel macho*, over the whole Spain.

Unluckily nothing can be said in a general way about block coefficients of hold in Portuguese ships. The empirical method using hoops and gauges to count how many casks could be stored in the hold was used throughout the whole sixteenth century to the beginning of the following. No formulas are known to have been used to determine net tonnage, but a mathematical relation existed between the later and the ship's dimensions. A formula had been proposed, but it is not possible to use it in a general way to extract the block coefficient of hold, because the vertical dimension used to determine net tonnage was not constantly proportioned to the other parts of the ship and it was situated much lower than it was done in the others examined Countries. The block coefficients of Portuguese ships can only be studied on a case by case basis.

Nothing is known about the methods to determine net tonnage used in Genoa in the sixteenth century. The only source providing some data on tonnage are notarial records of shipbuilding contracts. A Genoese *nave* built in 1546, 25 years before *Il Carteggiatore* was written, had a block coefficient of hold of 0.435, very near those of Ragusan ships, and her proportions were very similar too. The block coefficient of hold of another *nave* built in 1599 near Genoa, almost 30 years after Sagri's death, was 0.484, near the ones of Spanish ships of the time. Her proportions had moved away from those described by Sagri, as probably by that time Ragusan ships had made too.

Examining Genoese ships contracts in notarial records from the late sixteenth to mid-seventeenth centuries, a formula had been proposed in 1999. This doesn't imply that it was known or used at the time; it only explains which was the mathematical relation between ships' dimensions and net deadweight. The block coefficient of hold that can be obtained is 0.485, definitely nearer to those of Spanish ships than to the Ragusan ones. The formula fitted well the above-mentioned Genoese *nave* of 1599, but not the one of 1546, so in this chapter a modified version of the formula for net tonnage of Genoese ships in the mid-sixteenth century is proposed. A revision of measure units and conversion factors of the sixteenth century has allowed to determine that the *botte* used to transport liquids on board Genoese ships was not a local unit but a foreign one, different from those of Venice or Naples, and equivalent to the *pipa andaluza* (Table 7.5).

The block coefficients of hold obtained from tonnage formulas are compared, with particular reference to Sagri's and Barros' ones, known to have both considered measurements taken at the widest point of the ship. According to block coefficients of hold of these ships (considered to have similar proportions), Spanish ships were bulkier, with coefficients ranging from 0.475 to slightly over 0.500, while Ragusan ships were slenderer, with coefficients around 0.420–0.430. The only exception among Spanish coefficients is the one coming from the *Presidente-Visitador* formula, 0.444, definitely nearer to the Ragusan than to the Spanish ones. This formula was the only one considering the measure of the keel, as it was common in Venice since the late fourteenth century,[31] and will become in Great Britain in the late sixteenth century (Oppenheim 1896, pp. 132–133). After applying this formula to the Sagri's *nave*, the coefficient becomes 0.431, almost identical to the Ragusan ones. The place where the document containing the formula was written is unknown and for the above-mentioned reasons the latter could be of Mediterranean tradition. By the Ragusan side, some inaccuracy existed in the measure units equivalences proposed by Sagri and commonly used in the sixteenth century. After the correction according to modern metrology, the Ragusan coefficients become 0.400–0.460. The highest comes from Sagri's third formula, which used the 'western' measure units, the *gobiti*, that in his opinion were common 'out of Venice', 'through Italy and Spain', giving a possible interpretation of its nearness to the Spanish coefficients. The use of the above-mentioned block coefficients is a valuable tool to determine net tonnage (in m^3) of a sixteenth century ship, when her measures are known: just multiply Length by Breadth by Depth of hold (in metres) by one of the coefficient in Table 7.5 (ranging from 0.423 to 0.485), according to the origin of the ship, or by the average 0.454 if the origin is unknown. It is also possible to determine her net deadweight (in metric tons) by multiplying net tonnage (in m^3) by 0.72 t/m^3.

4 Conclusion

At the end of this study, *Il Carteggiatore* revealed the wealth of information it contains for the knowledge of Mediterranean naval architecture of Ragusan/Italian influence of the early modern period. The analysis of the dimensions and proportions of Sagri's *nave* allows us to reconstruct her, to compare her with what texts and

[31] 'Libro di navigar', *op. cit.*, f°18R.

Table 7.5 Block coefficients of hold from net tonnage formulas

Author/year	Sagri first formula 1571	Sagri second formula 1571	Sagri third formula 1571	Presidente Visitador formula c.1560–1570	Vargas formula c.1565–1575	Busturia 1568, Barros 1580, *Real Cedula* 1590	proposed formula for the Genoese *nave 'Bertorota'* of 1546 (Ciacchella)	proposed formula for the Genoese *nave 'S. Maria. in Betelen'* of 1599 (Gatti)
Original[a]	0.429	0.426	0.423	0.444	0.501	0.476	0.437	0.485
Corrected[b]	0.400		0.461					
Depth of hold / Breadth	0.5			0.5	0.5–0.53	0.5–0.53	(0.5) estimated	0.56
Breadth	1			1	1	1	1	1
Keel / Breadth	1.94			2.13	2	…	2.03	2.31
Length@ WL / Breadth	3			3.20–3.27	3–3.07	…	2.92	3.23

[a]according to the sixteenth century equivalences
[b]according to the modern metrology equivalences

archaeology tell us about the Mediterranean merchant ships of the time, and finally, to compare her with those built in the Iberian world.

Although the proportions of Sagri's *nave* appear to be widely used in European shipbuilding at the time, two out of the three net tonnage formulas he recommended for were unknown. They have been studied with an innovative method through the use of block coefficients. This allowed to go beyond what Length/Breadth/Depth proportions express, by showing that Italian/Ragusan ships were in general less bulky than those of Iberian shipbuilding with similar ratios and main dimensions.

Finally, it should be pointed out that this study does not deal with other important aspects that the manuscript highlights, in particular that of the ship's masting and sails, to which Sagri devotes a large part of his text (Chaps. 8, 9, 10, and 11 i.e. 23 folios), or that of anchors (Chap. 12). For a more in-depth knowledge of the ragusan *nave*, it will be worthwhile in the future to continue the work undertaken by a study of these themes.

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Chapter 8
Trade and Traders of North European Timber and Other Naval Provisions in Sixteenth-Century Seville

Germán Jiménez-Montes

Abstract This chapter analyses how the market of imported naval provisions functioned in Seville at the end of the sixteenth century. The primary source for this paper is a dataset of notarial deeds formalized by thirty north European merchants who specialized in the trade of extra-peninsular timber in the last third of the century. With an analysis of these operations, this chapter aims to offer wood scientists and nautical archaeologists an overview of the Baltic and Scandinavian naval products that were available in sixteenth-century Seville, and how they were traded.

8.1 Introduction

No local chronicle registered the death of Esteban Jansen in 1596, and no historian has ever paid attention to his presence in Seville, the economic capital of Spain at the time (Otte 2008). Born in Danzig, today's Gdansk, he migrated to Seville in 1575. There, he married the daughter of an influential Flemish merchant, Enrique Apart, who introduced him in the trade of Baltic and Scandinavian timber. In his testament, Esteban Jansen claimed that the monarchy owed him 25,000 ducats for masts and other timber that he had supplied to the royal navy and were still unpaid.[1] He was soon forgotten after his death, but his testament shows that, in life, he had become the greatest trader of imported timber in Andalusia, the southernmost region of the Iberian Peninsula and the main gateway between Europe and the Americas in the early modern period.

Although Esteban Jansen's importance was unparalleled, he was not the only one importing and trading north European timber in the region. We know of at least thirty merchants who specialized in the trade of extra-peninsular timber in Seville in

[1] Archivo Histórico Provincial de Sevilla (AHPSe), SP, 9289, 714r.

G. Jiménez-Montes (✉)
University of Groningen, Groningen, The Netherlands
e-mail: g.jimenez.montes@rug.nl

A. Crespo Solana et al. (eds.), *Heritage and the Sea*,
https://doi.org/10.1007/978-3-030-86460-6_8

the last third of the sixteenth century. They all shared similar experiences. Like Esteban Jansen, they immigrated from northern Europe, mostly from the Low Countries, and became involved in the trade of Baltic and Scandinavian timber after marrying the daughter of other compatriots who were already established in Seville. With their commercial activity, they ensured the supply of timber and other naval provisions for the preparation of ships sailing to the Americas. Eventually, these resources also became strategic for the monarchy to prepare the armadas and to build new Atlantic warships in Cantabrian shipyards, on the northern coast of the Iberian Peninsula. Paradoxically, their migration to Seville coincided with the beginning of the Eighty Years' War. The Calvinist uprisings occurring in the Low Countries in 1567 soon evolved into a civil war, which led to the independence of the northern provinces in 1581 (Van der Lem 2018). This was the beginning of a long-lasting war between two overseas empires, the Hispanic Monarchy and the Dutch Republic (Israel 1997).

The dependence on foreigners – and especially on potential enemies of the Spanish king, such as the Dutch – to cope with the struggles of maritime war has fed a narrative of failure of the Spanish navy. According to this, Spain was unfit to deal with the increasing military competition at sea, provoking a shipbuilding crisis and a consequent naval decline. This made Spain lag behind emerging Atlantic competitors from the end of the sixteenth century, the Dutch Republic and England (e.g. Thompson 1976). It is true that, by the end of the sixteenth century, a crisis of shipbuilding production started in the Cantabrian region, where most of the Spanish production of oceanic vessels was concentrated (Aragón Ruano 2008). Yet, like Regina Grafe (2011, p. 81), I wonder "[i]f Spain was so deficient in the naval arts, how did it hold together the largest western empire ever for three centuries?"

In "The Strange Tale of the Decline of Spanish Shipping", the German scholar relativizes such crisis. She offers an alternative explanation to the progressive deterioration of the Spanish naval reputation based on changes in demand. No genuine problems in the provisioning, manning or technology affected the Spanish navy more than other European powers of the time. Most challenges to the Spanish navy were common to all of them, like the need to import masts from Scandinavia and other Baltic regions. According to Grafe, together with an endemic lack of market integration, a transformation in naval activities in northern Spain due to changes in commercial routes, made Cantabrian shipyards unable – and somehow unwilling – to respond to the monarchy's increasing demand of large vessels, which were better prepared for oceanic navigation and war. The decline of shipbuilding production should not be directly associated with a decline in Spain's naval capacity. As I explained in my doctoral dissertation (Jiménez Montes 2020a), the creation of a market of imported timber represented an efficient solution for Andalusia to deal with the needs of a private market – the ships sailing to the Americas – and of the royal service – the construction of new warships and the preparation of the armadas.

This chapter analyses how the market of imported naval provisions functioned in Seville at the end of the sixteenth century. The primary source for this paper is a dataset of notarial deeds that these foreigners formalized during the period of 1570–1600, in which the trade of naval provisions are documented. In a similar way to today's notaries, pre-modern notaries were officials with royal authority to publicly formalize an agreement, attesting that a document explained such agreement in a true way and was correctly signed by the parties involved in it (Extremera Extremera 2001). Although not all agreements were necessarily registered before a notary, we can have direct or indirect access to many commercial operations through notarial deeds. With an analysis of these operations, this chapter aims to offer wood scientists and nautical archaeologists an overview of the Baltic and Scandinavian naval products that were available in the sixteenth-century Seville, and how they were traded.

This chapter is divided into three parts. The first one addresses the role of Andalusia as a logistical node within the Spanish maritime empire. The second presents the group of north European merchants that, based in Seville, dominated the trade of imported timber in southern Spain. The final section analyses the composition of the market of timber and other naval provisions in the region, establishing a categorization of products and how they were supplied to the privately-owned ships preparing to sail to the Americas, the royal navy, and other industrial activities that flourished in the city during the century.

8.2 Andalusia: A Poor shipbuilding Industry, A Main Logistical Node

Thompson (1991, p. 88) explained that, in the last three decades of the century, Spain experienced a process that he called "*Atlanticisation* of war", which implied a change in "the framework of association between Castile and Spain and between Spain and the Mediterranean kingdoms". After the Holy League's victory over the Ottoman Empire in 1571, a *status quo* emerged on the Mediterranean front between the Turks and the Spaniards (Braudel 1949). At the same time, Atlantic affairs became more prominent for Philip II. The incorporation of Portugal in 1580, the frequent military conflicts with England, and the war in the Low Countries had a profound impact on the organization of Spain's navy (Gómez-Centurión Jiménez 1988; Thompson 1991).

The *Atlanticisation* of war implied the *Atlanticisation* of the royal navy. Historians agree that Philip II was the first king with a conscious plan for improving the royal navy (Stradling 2004; Casado Soto 2006), and a consistent policy on naval matters (Martínez González 2015; Wing 2015). During his reign, Philip II implemented ambitious plans to increase the number of Atlantic warships, especially high board galleons fitted for oceanic wars and longer journeys than Mediterranean galleys (Casado Soto 2006). The monarchy directly administered and financed the construction of new warships, and also offered tax exemptions and generous loans to private shipbuilders, under the condition that the new ships could be eventually seized by the monarchy for military campaigns (Thompson 1976; Casado Soto 2006).

Most of the new warships were constructed in Cantabrian shipyards(Casado Soto 1988, 2006). The Cantabrian coast was not uniform but a rather diverse area, where local communities with different jurisdictions had a long tradition in the trade with the Low Countries and seasonal whaling, especially along the Basque coast. These local communities had a long expertise in the construction of ocean-going vessels, and access to quality forestry resources, especially oak. The region lacked quality pine trees for the masts, which had to be imported from northern Europe (Casado Soto 2006). Andalusia did not participate in the monarchy's shipbuilding projects due to the low quality of timber in southern Spain. The monarchy even forbade the participation of Andalusian-built ships in the *Carrera de Indias* for this reason (Rodríguez Lorenzo 2017). Only in the eighteenth century was a royal shipyard created in Andalusia. The *Arsenal de la Carraca* in Cádiz, which had originally been a repair yard, developed into a royal shipbuilding center in the eighteenth century, when the pines from the Sierra de Segura and Cazorla became accessible and exploitable (Crespo Solana 1995).

While lacking a competitive shipbuilding industry, there was an important industry in Andalusia for the maintenance and repair of the ships sailing to the Americas. Andalusia played a fundamental role in the logistical organization of the *Carrera de Indias*, as the navigation and trade between Spain and the Americas came to be known (García-Baquero González 1992). In 1503, the Spanish queen Isabella I of Castile established the House of Trade of the Indies in Seville to supervise the organization of the *Carrera de Indias* (Acosta et al. 2004), and the city became the only Castilian port allowed to trade with the Americas. However, most of the shipping activities of the *Carrera de Indias* did not occur in Seville, but on the western Andalusian coast, between the ports of Sanlúcar de Barrameda and Cádiz (Pérez-Mallaína 1997).

In the decade of 1560s, Isabella's great grandson, Philip II, implemented an ambitious set of regulations for the *Carrera de Indias*, which strengthened the region's position as a main node of the Spanish maritime empire. These regulations required ships of the *Carrera de Indias* to travel in convoy, according to a determined sailing calendar, controlled the size and arming of the ships, and established a military fleet to escort them (Phillips 1986). Two annual fleets departed from Andalusia every year: one in April heading to Nueva España and another in August heading to Tierra Firme. Returning ships met in La Habana, from where they undertook their journey back. The American convoy system prevailed with minor changes during the whole Habsburg period (Díaz Blanco 2014).

In this period, Andalusia began to assume new logistical operations for the royal navy, in the context of the *Atlanticisation* of the navy. The region, in-between Mediterranean and Atlantic waters, became a principal theatre of that transformation. As tensions between Spain and the Ottoman empire decreased, the fleet of royal galleys began to hibernate in Andalusia instead of Sicily. Moreover, in 1580, the king established a commissariat in Seville for victualling the royal navy and, in 1586, in the context of preparation of the Gran Armada against England, the king appointed in Seville a general purveyor of the royal navy; another general purveyor was established in Lisbon (Thompson 1991). The new appointments reveal that, despite the deficiencies of Andalusia's shipbuilding, the region offered the monarchy access to the supply of strategic resources for the royal navy, thanks to the emergence of a competitive market of imported naval provisions.

8.3 Timber Traders in Seville

In my doctoral dissertation(Jiménez Montes 2020a), I concluded that the support of Seville's oligarchy to north European merchants was a main factor in the emergence and consolidation of a market of imported naval provisions. Although this support collided with Philip II's policy of commercial war against the Dutch Republic, which translated into three embargoes upon the trade with northern Europe (1574–1579, 1585–1590, and 1595–1596), the population of north European migrants experienced a sharp growth in Seville in the second half of the century (Stols 1971). The number of north European merchants who, based in Seville, specialized in the trade of imported timber grew too.

The trade of imported timber, which became a flourishing activity in the period, soon fell into the hands of only a few families. Notarial deeds reveal that there were at least 30 individuals residing in Seville permanently who dealt with Baltic and Scandinavian naval resources in the period from 1570 to 1598. They all identified as Flemish or German merchants (*mercaderes flamencos* or *mercaderes alemanes*), even though some had migrated from the Dutch Republic, Baltic towns like Danzig or were second-generation migrants who had been born in Andalusia. Most of them started in the timber trade working as interns of older compatriots and, eventually, started a commercial firm of their own after they married. They were not the richest merchants in the city, but were affluent enough to participate in long-distance trade, invest in real-estate and, in some cases, trade with the Americas. The descendants of some of these families would eventually join Seville's commercial elite (Jiménez Montes 2016a). Although the market was organized in individual firms, their intertwined kinship network created a proper environment for the cohesion of the group, which avoided external and internal competition and favoured the establishment of commercial collaborations.

Another reason for this cohesion was their residence in the same area, the *Reales Atarazanas*, which became the main location for the trade of imported naval provisions in Andalusia. This was a large building complex, which was formed by 17 large naves and situated between the city's economic heart (around the Cathedral) and the bank of the Guadalquivir River (Pérez-Mallaína 2010). North European merchants built their houses and warehouses inside the naves, where they could store large tree-pieces. A probate inventory of one of these merchants, Manas Enriquez, provides a glimpse of the capacity of one of these houses.[2] When Manas Enriquez died, his executors reported the following timber stored in his house: 104

[2] AHPSe, SP, 9271, 197r-v.

dozen pine planks, 78 small pine trees, 55 large yards, 600 small yards, 49 half oak trees, and 4737 barrel staves. Moreover, he had five piles of planks amounting 400 dozen "in the street" and 31 pine beams "by the door".

Unfortunately, the pieces of timber are not described in detail, and there is no information about their size or price. Hence, it is not possible to estimate the volume of the stock or its market price. Yet several conclusions, which can apply to the rest of Flemish and German merchants, can be drawn from a further look at Manas Enríquez's probate inventory. One is that he barely diversified his commercial activity. Manas Enriquez owned a salt pond on the coast, in Puerto Real. This is not surprising, as salt was the second most traded commodity in the routes between northern and southern Europe and was highly demanded in northern markets (Mollat 1968). Besides the listed timber, the salt pond and his personal belongings, the inventory does not report any other tradable commodity at his house. We know from the inventory that several men owed him 400 ducats from commodities that he had sent to the Americas. We know nothing about the reasons for these debts, but we can assume that they had originated in the trade of Flemish textiles, which were the other main commodity that north European merchants used to import from the Low Countries (Jiménez Montes 2016b). A second conclusion is that they had a varied stock of timber – from large pieces to planks, from oak to pine – and that part of this stock was left outside the building of the *Atarazanas*. This practice of leaving large pieces on the sand bank in front of the *Atarazanas* is beautifully portrayed in many of the city's views, especially in the one of the 1570s attributed to Alfonso Sánchez Coello.

Finally, it is important to consider that not all trade of timber occurred in Seville, and not all of these merchants' stock was stored in the city. Many transactions took place eight leagues away from Seville, in the port of Las Horcadas. According to Pérez-Mallaína (1997), ships larger than 500 tons very rarely completed their journey up to Seville and normally anchored in Las Horcadas, where merchants—or they employees—received the timber freights from north European ships and sold them to Spanish ship captains (Jiménez Montes 2020b). Moreover, many vessels did not even enter the Guadalquivir river and stayed at the mouth, in Sanlucar de Barrameda, or in nearby ports, like Cádiz. Flemish and German merchants based in Seville extended their network of contacts to those ports along the Andalusian coast, and many had warehouses there.[3]

8.4 The Market of Timber and Naval Provisions

Notarial sources provide a rich overview of the degree of specialization achieved by the market of timber and naval provisions in Seville. Two sets of notarial deeds are particularly revealing: promises of payment and bills of receipts. In the first, a

[3] e.g. AHPSe, SP, 9266, 600v.

debtor promised a timber merchant to fulfil a payment for the sale of naval provisions before a certain date. These deeds were usually formalized by ship masters and owners of the *Carrera de Indias,* who bought naval provisions for the preparation of their vessels before sailing. In the second, the timber merchant recognized to receive a payment from a royal official for a service to the monarchy; in this case, timber for the provision of the royal navy. Not all transactions were publicly registered in the notaries, as no local or royal law required merchants to formalize their commercial operations before a notary. If the two parties of a transaction knew each other well, they would just reach a verbal agreement and account the operation in their own ledgers; these private accounts could then be used in court if needed. (Trivellato 2009). Sadly for historians of the sixteenth-century Seville, almost none of these private ledgers have survived. Luckily, other notarial deeds can give information in an indirect way, such as testaments or powers of attorney. Through powers of attorney, for instance, a merchant could commission a proxy collection of a debt, which had originated from a sale of timber.

If a transaction was notarized in a direct or indirect way, it is very likely that the involved parties were interested in stating the conditions of the products at the time of the operation. Because of this, notarial deeds usually contain a description of the traded naval provisions. The degree of detail varied depending on the type of notarial deed; they tend to be more exhaustive in promises of payment, which involved a payment in credit and risk clauses. Moreover, there was not a standardized method of description, which hinders a complete analysis on the state of the market, especially regarding prices or the volume of trade. However, by looking at the different attributes that were used to describe naval provisions, we can grasp the wide offer of products available at the warehouses of the *Atarazanas* and identify some of the key factors that drove their demand.

Table 8.1 shows the diversity of commodities that were sold in the *Atarazanas* with a translation (second column), according to notarial deeds. The third column indicates the unit used to sell each type of product and the fourth column contains the attributes that were used in notarial deeds to describe them. The fifth column categorizes the type of attribute according to the nature of the description: function within the ship, provenance, size, species, type of sawing, and quality. In the table, the types of products are divided into four groups (first column). The first consists of large- and complete-tree pieces, like masts and yards, onto which the sails would be set. The second is sawn timber, which represented smaller pieces that had been processed to be used for construction like planks, and specific devices built in timber, like mast-steps. A third group is formed by the rigging, which included a variety of cordage products. Lastly, there are products for caulking the vessels' hull and waterproofing timber.

In many notarial deeds, especially promises of payment and bills of receipt, the quantity of the traded product was specified carefully, indicating the number of products and, to a lesser extent, their measure. Trees and other large timbers were often sold per piece, but smaller timbers were usually sold in groups. Planks, for instance, were sold by the dozen (sing. *Docena,* pl. *docenas*), although certain types of higher quality timber, like oak planks and Prussian planks, could be sold per piece. Cheaper sawn timbers, like barrel staves (*duelas* or *tripitrapes*), were sold in groups of 1045 pieces, also known as *millar* (sing.) or *millares* (pl.). Finally, rigging products were sold in different sizes and forms, like *cables* (cables), *guindalesas* (hawsers) or *jarcia* (cordage) but measured in *quintales* (quintals), which was a Castilian weight measure equivalent to 46 kilogrammes. Caulking products were sold in *quintales*, too, although pitch was often measured in *barriles* (barrel), which was a Castilian liquid measure equivalent to about 35 litres.

Timber pieces (sawn or complete) could be measured in palms, like masts.[4] We know, for instance, that the size of *tripitrapes* could range from four to five and seven palms.[5] Notarial deeds are not very exhaustive when it comes to the size of the product. Most just vaguely describe the size of the product adding an adjective, like *grande* (big) or *pequeño* (small).[6] Sometimes, a diminutive (*vigueta*) sufficed to indicate a small size.[7] It is very difficult to determine the implications of size variations other than the obvious fact that shorter pieces must have been cheaper than larger ones.

There were also references to quality, which surely affected the price of the commodity. The name *suerte* (kind) was used to detail the quality degree of the product, like in *suerte mayor* (high quality)[8] or *primera suerte* (first kind).[9] The type of sawing was indicated when relevant, like in *tablas aserradizas* (planks with a serrated edge), which reveals the high degree of specialization achieved by the market.[10] Another indication of such specialization is the sale of devices made in timber, like oars. In 1591, a ship repairer (*carenero*) called Juan Antonio Remolar bought 324 "large oars" from the house of Esteban Jansen, for a price of 8,5 *reales* for each oar.[11]

Many attributes served to describe the function of the product within the ship. This was especially the case for large pieces of trees, which were normally defined by their future position in the ship as mizzen mast[12] or bowsprit.[13] Some references to the function of a piece of timber make it difficult to tell the difference between two products; for instance, between trees for yards ("*árboles para verga*"[14]) and yards ("*vergas*"[15]). Very likely there was no difference, evidencing the ambiguity of notarial sources.

4 e.g. AHPSe, SP, 9284, 119r.
5 AHPSe, SP, 9247, 428v.
6 e.g. AHPSe, SP, 9247, 428v; 9224, 749r.
7 e.g. AHPSe, SP, 9299, 335r.
8 e.g. AHPSe, SP, 9306, 519r.
9 AHPSe, SP, 9306, 516r.
10 AHPSe, SP, 9222, 109v.
11 AHPSe, SP, 9266, 850v
12 AHPSe, 9250P, 716v.
13 AHPSe, SP, 9268, 1026r.
14 AHPSe, SP, 9275,927r.
15 AHPSe, SP, 7784, 404r.

The species of the timber certainly influenced the quality of the product, and therefore, its price. The way notarial deeds describe the provenance of products is one of the most interesting aspects of the market. The labelling of the product according to provenance must have worked like today's designation of origin, adding value on commodities by associating them with a specific place. Many references indicate that products came from Flanders (*Flandes*), like *tablas de pino de Flandes* (pine planks from Flanders[16]). Flanders was used here as a name to refer to the place from where the planks were imported rather than to describe the provenance of the pine. Obviously, the pines sold in Andalusia were not originally from the Low Countries, as the region had to import pines as well (Jou 1992). It is possible that sources make a reference to the Low Countries because it was there where raw trees were processed and sawn in a distinctive plank-shape, which was appreciated in southern Europe.

Such a regional trademark, in any case, speaks of the importance of the Low Countries as an intermediary node in the trade between northern and southern Europe (De Vries and Van der Woude 1997). Other geographical references, especially to *Alemania* (Germany) or *Prusia* (Prussia), appear in a lesser extent. In this case, the provenance of timber may be the Baltic axis between Danzig and Konigsberg (Jou 1992). In any case, references to product origins highlights the obstacles of addressing the provenance of timber when relying on written primary sources only.

Exceptionally, these merchants sold regional timbers, like *pinsapos* (Spanish fir). Pinsapo was mostly used for planks,[17] but there is also evidence that they could be used for masts.[18] However, the use of *pinsapos* for masts is extremely unusual if compared to the use of north European pine; it must have occurred in times where the stock of imported trees was scarce. We also document sporadic references to timber from Reus, in northern Spain,[19] and various mentions to tar from the Canary Islands[20] or Biscay.[21]

At this point, it should not come as a surprise that the majority of the naval provisions sold by these merchants was imported. It should not come as a surprise either that pine masts were one of the most demanded provisions. As mentioned earlier, the Iberian Peninsula was rich in oak, especially in the northern area, and Mediterranean pine, both of which were widely used in Iberian shipbuilding. Yet shipbuilders preferred north European pines for the masts, as these trees had better quality than their Iberian counterparts, according to contemporary intellectuals (De Artíñano y de Galdácano 1920). Scandinavian pine (*pino*) was used for the repair of the ships of the *Carrera de Indias*, as masts and yards suffered during the oceanic

[16] e.g. AHPSe, SP, 9275, 927r.

[17] AHPSe, SP, 9273, 983r.

[18] AHPSe, SP, 9266, 600v.

[19] AHPSe, SP, 9290, 730r.

[20] AHPSe, SP, 9223, 47r.

[21] AHPSe, SP, 9298, 776r.

journeys and had to be replaced before sailing again to the Americas. For instance, the ship owner Juan Martínez de Echaverria promised to pay 1500 *reales* for two trees, one for the main mast and the other for the foremast, 420 reales for tar and 725 *reales* for 7,5 dozen pine planks "to fix" (*aderazar*) his vessel which was in Sanlúcar de Barrameda waiting to sail to San Juan de Ulúa, New Spain.[22]

We know of at least 113 promises of payment in which ship owners or masters of the *Carrera de Indias* bought provisions. This number must be significantly lower than the actual number of times in which masts were supplied to fix ships of the *Carrera de Indias*; because ship owners and timber merchants knew each other well, there was little incentive to formalize a transaction before a notary. Due to the lack of notarized transactions, the information on prices stated on promises of payment and other notarial deeds is not consistent enough to draw conclusions over price variations; in my dissertation (Jiménez Montes 2020a), I could only show an overview of prices.

Nonetheless, the case of Juan Martínez de Echaverría evidences some interesting aspects about the supply of naval provisions to the ships of the *Carrera de Indias*. One is that, while the ship was being repaired on the coast in the port of Sanlúcar de Barrameda, ship owners bought imported timber in Seville. Moreover, masts were not the only products that ship owners bought from the *Atarazanas*. They obtained a diverse range of provisions to repair and prepare their ships, such as tar and planks. Rigging was also very much in demanded by ship owners of the *Carrera de Indias*. As rigging suffered heavily during oceanic journeys, it had to be replaced frequently. This provision, as seen in Table 8.1, was imported from the Low Countries, too, and a popular way to refer to it was *jarcia de Flandes* (rigging from Flanders[23]).

Indeed, the market of the *Atarazanas* offered a wide range of imported provisions, even though some species must have been available in Andalusia or the Iberian Peninsula, like oak. The higher quality of the imported commodities may explain this. A good example of the reputation of imported timber is that, in 1578, Gerónimo Andrea, Esteban Jansen, and Felipe Sarens sent there 200 *bornes* (oak trees) for the construction of the organs of San Lorenzo del Escorial, the palace that Philip II built in Madrid.[24] Quality may not be the only reason for the popularity of imported timber. According to Rodríguez-Trobajo and Domínguez-Delmás (2015, p. 154), imported timber was cheaper than regional material. In their study on the construction of an altarpiece in Lucena, a village in Cordoba, they concluded that regional oak was far more expensive than the Swedish oak used in the same work. The price of the first was 7 ducats per piece while the second was 1 ducat per piece.

This is a good example of how, while the market emerged to keep ships of the *Carrera de Indias* in shape between voyages, it evolved into a diverse market that supplied different sources of demand, including local industries. One particular local group that benefited from this market was the guild of coopers. In the notary,

[22] AHPSe, SP, 9274, 120r.

[23] e.g. AHPSe, SP, 9272, 589r.

[24] AHPSe, SP, 9219, 365r.

Table 8.1 Typology of naval provisions available in sixteenth-century Seville

	Product/Translation	Unit	Attribute	Type of attribute
Complete- and large-tree pieces	Entena / type of yard	Piece	Entenuela	Size
	Árboles / trees	Piece	… para entenas	Function
			… para bauprés	Function
			… para vergas	Function
			… para mastilejos	Function
			… para trinquete	Function
	Berlinga / type of yard	Piece		
	Borne / Oak tree	Piece	Bornete	Size
			Medios bornes	Size
			… de Madera de Flandes	Provenance
			… de marca mayor	Quality
	Mástil / mast	Piece	… de pino	Specie
			… de pinsapo	Specie
			… para trinquete	Function
			… para verga	Function
			Mastilejos	Size
			… pequeños	Size
			… medianos	Size
			… grandes	Size
			… grandes de Prusia	Size
	Palo / spar	Piece	… de pino Para mesana	Specie + function
			… de roble	Specie
			… para mastelillos	Function
			… para mástil	Function
			… para trinquete	Function
			… para verga	Function
	Pino / pine	Piece	Pinete	Size
			… de Flandes	Provenance
	Verga / yard	Piece		
Sawn timber & timber devices	Barraganete / deck coaming	Piece		
	Duela / stave	Millar (1000 pieces)	… de Alemania	Provenance
			… de Flandes	Provenance
			… de Irlanda	Provenance
			… de pique Para hacer pipas	Quality + function
	Espigón /?	Piece		
	Pontón /?	Piece		

(continued)

Table 8.1 (continued)

	Product/Translation	Unit	Attribute	Type of attribute
	Posavergas / yard-holders	Piece		
	Remo / oar	Piece		
	Tripitrape / pipe stave	Millar (1045 pieces)	… de marca mayor	Quality
			… para pipas	Function
			… de a cuatro palmos	Size
			… de a cinco palmos	Size
			… de a siete palmos	Size
			… grande	Size
			… pequeño	Size
	Tabla / plank	Dozen/ piece	… de pino aserradizas	Specie + sawing
			… de pino de Flandes	Specie + provenance
			… de pino de Reus	Specie + provenance
			… de pinsapo de suerte mayor	Specie + quality
			… de pinsapo de primera suerte	Specie + quality
			… de pinsapo de segunda suerte	Specie + quality
			… de pinsapo de tercera suerte	Specie + quality
			… de prusa fina	Provenance + specie
			… de roble planchadas	Specie + sawing
			… gordas	Size
			… grandes	Size
			Medias tablas	Size
			Tablones	Size
	Viga / beam	Piece	… de Flandes	Provenance
			… de pino	Specie
			… de roble	Specie
			Viguetas	Size

(continued)

Table 8.1 (continued)

	Product/Translation	Unit	Attribute	Type of attribute
Rigging	Cable / cable	Quintal	… alquitranado de Flandes	Quality + provenance
			… de cáñamo	Specie
	Calabrote / small cable	Quintal	… alquitranado	Quality
			… usado	Quality
	Cáñamo / hemp	Quintal	… alquitranado	Quality
			… alquitranado de Alemania	Quality + provenance
			… de Flandes	Provenance
	Guindalesa / hawser			
	Jarcia / cordage	Quintal	… alquitranada de Alemania	Quality + provenance
			… alquitranada de Flandes	Quality + provenance
			… basta	Quality
			… en piezas	Quality
			… de Alemania	Provenance
			… de Hilo de Flandes	Quality + provenance
			… en cables	Quality
			… en guindalesa	Quality
			… menuda	Quality
			… para cáñamo	Function
Coating	Alquitrán / pitch	Barril		
	Brea / tar	Quintal	… de Flandes	Provenance
			… de Vizcaya	Provenance
			… negra de Canarias	Quality + provenance

Source: AHPSe, SP, 7764–7786 and 9214–9308. (Castro et al. 2018)

we find 114 promises of payment in which coopers declared their debt to a merchant of the *Atarazanas* for the supply of staves; either *tripitrapes* (probably of lower quality) or *duelas*. Coopers usually bought in bulk, at least in the notarized transactions, buying by the hundred[25] or by the thousand.[26] The merchants of the *Atarazanas* also provided rigging to cable makers,[27] tar and pitch to ship caulkers,[28] and timber

[25] e.g. AHPSe, SP, 9292, 194r.

[26] e.g. AHPSe, SP, 9297, 609v.

[27] e.g. AHPSe, SP, 9243, 404v.

[28] e.g. AHPSe, SP, 9280, 1067r.

to carpenters,[29] builders,[30] and sculptors.[31] Their timber even became important for the social life of the city. We know that, in 1591, the Dutch merchant Guillermo Corinse rented to the city council ten dozen planks for the construction of a bull fighting ring during a local festivity.[32]

The development of such a competitive market soon attracted the attention of the royal officials. They resorted to the warehouses of the *Atarazanas* to supply the galleys operating in Andalusia (e.g. "the Armada Real de Guarda de las Yndias"[33]), the preparation of diverse military campaigns (e.g. the one in the Azores in 1583[34]) or the construction of new royal warships in the north of Spain.[35] The fact that Cantabrian shipyards were supplied with timber re-exported from southern Spain, instead of timber directly imported from northern Europe, evidences the development of Seville's market of naval provisions. This market, which emerged to supply the growing demand of the *Carrera de Indias*, evolved into an essential node for the supply of the royal navy. The commercial activity of the north European merchants operating in the *Atarazanas* made this evolution possible.

8.5 Conclusions

With the *Atlanticisation* of war experienced by Spain in the last third of the sixteenth century, Seville strengthened its position as a main logistical centre of the Spanish maritime empire. This chapter has demonstrated that a key factor for this was the creation of a market of naval provisions, which could respond to the increasing demand from the *Carrera de Indias* and from the royal navy. This market emerged in the 1570s, with the arrival of north European merchants who established themselves in the building complex of the *Atarazanas* and specialized in the importation and supply of naval provisions. Some of the products available at the *Atarazanas* were strategic to the city and the monarchy, such as quality masts, because they were scarce in the Iberian Peninsula and had to be imported from Scandinavian and Baltic forests. Other provisions, like planks or rigging, could be found in the Peninsula but were imported because of their higher quality and more competitive price. With time, these foreign merchants offered a wide diversity of naval provisions, which can be categorized into four main groups: large- and complete-tree pieces, sawn timbers and specific timber devices, rigging, and caulking products.

[29] e.g. AHPSe, SP, 9235, 14v.

[30] e.g. AHPSe, SP, 9215, 908r.

[31] e.g. AHPSe, SP, 7782, 63r.

[32] AHPSe, SP, 9526, 694v.

[33] AHPSe,9226P,401r.

[34] AHPSe,9273P, 262r.

[35] e.g. AHPSe, SP, 9269, 823r-823v.

Thanks to the descriptions appearing in notarial deeds, this chapter has addressed the specialization achieved by these foreign merchants. The attributes used in notarial deeds to describe products – such as size, quality, species, type of sawing, function within the ship, and provenance – are a valuable source for wood scientists and naval archaeologists to understand the complexity of the market. These provide a valuable complementary insight into archaeological remains on the type of timber used in Spanish ships. However, notarial deeds must be used with caution, as information is normally vague and, more often than not, inaccurate. A good example of this is the way deeds made a reference to the provenance of commodities. Many imported provisions are labelled as products from Flanders, even though most provisions imported into Spain in the sixteenth century came from Norway and the Baltic area between Danzig and Konigsberg.

Nonetheless, those geographical labels do indicate one important reality: the key role that the Low Countries, as well as Dutch, Flemish, and German agents, played in the trade between the Baltic and the Iberian Peninsula. By attracting the arrival and activity of north European merchants, Seville ensured access to strategic resources, which were essential for the *Carrera de Indias* and were ultimately used for the supply of the royal navy. With the creation of the market of imported naval provisions, in short, the city decisively contributed to the *Atlanticisation* of the Spanish navy.

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Chapter 9
Supplying Timber for his Majesty's Fleets: Forest Resources and Maritime Struggle in Portugal (1621–1634)

Koldo Trápaga Monchet

Abstract It is noteworthy that there were various trade routes by which timber was imported from Northern Europe to Portugal. This chapter however focuses on the forests in Portugal belonging to the Crown and some others located in Portugal that were exploited for the King, although they were owned privately. This does not mean that there were no other territories and forests within Portugal devoted to this purpose, as indeed they were. For that reason, this contribution is restricted to both ships used in the King's fleets and the *Carreira da India*. The maritime and military conflicts of the Spanish Monarchy led to the development of an intensive and spectacular shipbuilding industry, and Portuguese forests did not have the capacity to effectively supply the entire demand of timber for shipbuilding.

1 Introduction: Timber Competition in Portugal

As John Richards has pointed out, throughout the seventeenth century shipbuilding and ship repairs became the largest industrial establishment in Europe (Richards 2001, pp. 203–204, 224–227). This explains why sovereigns strove to maintain a supply of timber and why the use of timber in England, Scotland, and Ireland decreased sharply throughout the seventeenth century. This led to the proliferation of laws, orders, and regulations aimed at protecting home-grown trees. Portugal was most likely one of the maritime powers that might have faced similar challenges during the time period examined. Timber requirements forced sovereigns to take measures to protect such valuable raw material. Furthermore, during this period, European "societies rely on colonization, diplomacy, and military ventures" to ensure the ongoing flow of timber (Perlin 2005).

K. Trápaga Monchet (✉)
Universidad Rey Juan Carlos, Madrid, Spain
e-mail: koldo.trapaga@urjc.es

A. Crespo Solana et al. (eds.), *Heritage and the Sea*,
https://doi.org/10.1007/978-3-030-86460-6_9

Unlike Spain, which has been widely studied, there is little research on seventeenth-century Portuguese forested areas in relation to maritime struggle (Martínez González 2015, pp. 78–114; Wing 2015, pp. 122–164). Carla Rahn Philips has studied the contract signed between Martín de Arana and the Spanish Monarchy for which the former built six galleons during Philip IV's kingship. Her study encompasses the whole construction process, including the ship's lifetime, and the supply of materials and components, including timbers (Phillips 1991 for timber pp. 127–130).

In relation to Portugal, Leonor Freire Costa has studied the shipbuilding industry in Lisbon throughout the sixteenth century (Costa 1997). Nicole Devy-Vareta has mainly focused her interests on an earlier time period, providing some interesting insights into the Monarchy's timber legislation for shipbuilding throughout the sixteenth and seventeenth centuries (Devy-Vareta and Alves 2007, pp. 63–68). Cristina Joanaz de Melo has examined the forested areas belonging to the Crown at the end of the eighteenth century and beginning of the nineteenth, known as *matas* and *coutadas* in Portuguese (Hespanha 1989, p. 173; de Melo 2015). Felix Labrador Arroyo has correctly asserted that *matas* and *coutadas* were administered and safeguarded by the *monteiro-mor* and local *monteiros* and *couteiros*. The *monteiro-mor* was theoretically in charge of any matters related to hunting activities arranged for the royal family since at least the fourteenth century (Labrador Arroyo 2009, pp. 222–241). There are other scholars who have studied the Portuguese maritime industry in terms of environmental and political history, but a systematic study that focuses on these forested areas used for shipbuilding has yet to be conducted (Duffy 1955, pp. 50–52; Boxer 1969, p. 56). Timber and trees are indeed two of the main focal points of this paper.

In terms of the protection of forests and the shipbuilding industry, is it possible to differentiate between forest and tree, wood and timber? Although it is not possible to answer this question with the sources we have, we seek to add some knowledge about this issue by examining primary sources stored in Portuguese and Spanish Archives that have not been used as much as they could have been.

The term "forest" or "woodland" is understood here as a group of trees—sometimes perhaps a stand of trees—that comprise a forested area. Once the tree is cut it is referred to as "wood", whereas timber refers to the wood once it has been prepared, seasoned, and transformed into timber devoted to shipbuilding purposes. We do not attempt to make a clear distinction between wood and timber, as the documentation did not clearly state when or where the wood was "transformed" into timber, but rather to focus on the circuit of transport from forest to shipyard.

It is certainly highly challenging to assess the extent of the forested areas of Portugal prior to the twentieth century. The amount of timber and wood that was consumed in Portugal throughout early modern age cannot readily be determined. However, some scholars have sought to analyse the evolution of forest cover in Portugal providing a handful of insights on the early modern age. Throughout the early modern period in Portugal there was a shortage of timber; therefore, the kingdom was forced to import it from Europe and other regions (Reboredo and Pais 2014, pp. 11–14). Such circumstances led to a competition encompassing the whole society: from the King to local peasants of areas such as Santarém. Each person and institution defended their own interests, which theoretically were the King—and the Crown—the idealized institution committed to guaranteeing the common good. As access to timber became more difficult, so conflicts arose over access to and the use of this valuable raw material leading to "stiff timber competition" between inhabitants and institutions of Portugal.

In terms of shipbuilding, the Baltic region had been a supplier since the thirteenth century, probably the largest one worldwide. Portuguese kings extended several charters and privileges to Northern traders to make timber importation easier, especially for some ship components that were lacking in Portugal (de Oliveira Marques 1959, pp. 77–79, 145–151, 155–160). At this point several doubts arose about what the common good meant for Philip III and Philip IV regarding the forested areas of Portugal. Did it mean ensuring that everybody had access to indispensable resources such as wood? Or, on the contrary, did it mean conserving the heritage and bequeathing it to the future generations without any loss of territory? In terms of the latter question, we have some idea of what kind of heritage[1] was of interest to the Crown or, otherwise, to the nobility, or local farmers. This article focuses in particular on the territories of the Portuguese Crown—which are understood as a personal and familial heritage belonging to the Spanish Habsburgs—which the sovereigns did make a strong attempt to conserve in order to pass them on to their heirs. This concern is connected to military conflict and therefore to the concern of preserving forested areas for shipbuilding above the daily life necessities of local inhabitants.

In terms of the time period of this study, 1621 has been selected in this article as a starting point because it was the year in which Philip IV succeeded Philip III on the throne and the truce signed in 1609 with the Dutch Republic expired. The importance of 1634, however, requires a longer explanation. In 1634, the Trade Company that had been set up in Lisbon in 1628 to strengthen the Portuguese presence in Asia was disbanded. That year, the Spanish ministers who had settled in Lisbon claimed that the Portuguese forests were unable to carry on providing quality timber to build seaworthy vessels. Lisbon's shipyards were also criticized because of the high costs of construction, in part due to the poor quality of the timber. They proposed both deploying Galician oak instead of local species and decreasing shipbuilding activity in Lisbon. Moreover, in 1634 Olivares and Philip IV appointed a member of the royal family—Margaret of Saboy—as viceroy of Portugal after more than 40 years of government upheld by ecclesiastics and nobles. Thus, social, environmental, political, and economical factors come together to make 1634 significant as the closing year for the time period studied in this article.

By 1621 the Portuguese Monarchy had already been involved for almost two centuries in overseas expeditions in Africa, Asia, and South America. Ongoing shipbuilding activity had, thus, taken place in Portugal that affected the Portuguese forested areas. According to shipbuilding treatises in Portugal, especially in the area

[1] For heritage we mean the Spanish Monarchy, including overseas territories.

of the Tagus River, Cork oaks, stone, and maritime pines were mainly used for shipbuilding, because these were the main species available in Portugal (Domingues 2004, Chaps. 2, 3, and 4).

The stone pine is a fast-growing tree with a great reproductive capacity that can grow up to 40 m high, which makes it ideal for the construction of large ship components (Correia et al. 2007, pp. 18–24). The maritime pine, on the contrary, grows in poor soils all over Portugal: from Coimbra to the areas beyond the Tagus River, including Leiria, Azambuja, or Alcácer do Sal (currently known as *Mata de Valverde*). It was highly valued for shipbuilding because it absorbs little water and is resistant to several insects (Costa 2007, pp. 109–114). The cork oak is a slow-growing tree that has been very common in Portugal since at least the modern period (Costa and Pereira 2007, pp. 18–27). Nowadays, 23% of the forested areas of Portugal still consist of maritime pine and cork oaks (Silva 2016, pp. 15–16).

Consequently, the long-lasting overseas navigation tradition in Portugal steadily depleted its forested areas. Furthermore, as the years went on there was less quality timber suitable for shipbuilding because the trees that were in demand required more time to grow than the Portuguese shipbuilding activity could afford to wait. This led to a "wood-deficit", as Portugal consumed more wood and timber that it produced. The Portuguese did not give the trees time to become straight, thick, and tall enough before felling, which inevitably had negatives consequences, as we will point out afterwards.

The research conducted by Francisco Alves, Filipe Castro, and other nautical archaeologists in Portugal shows the poor quality of the timber used in Portugal for construction of the Cape shipping carrack *Nossa Senhora dos Martires*, which was shipwrecked in Cascais in September 1606. The excavations revealed a wooden structure that survived over an area of 7 by 12 metres (Castro 2003, pp. 11–12). At the time of the carrack's construction, there were not enough straight and tall cork oaks and pines available, so irregular wood was used for the frames (Castro 2003, pp. 12–14, 2005, pp. 105–118). Archaeological evidence matches the information revealed throughout this article; thus it can be stated that during the years studied here, the timbers used to build ships in Lisbon were not very sturdy. This was perhaps, or in part, due to the poor quality of the wood used for the construction of the vessels.

This disadvantage was pointed out by several people from very diverse fields of expertise. In 1621 Philip III passed away, and soon after the merchant Duarte Gomes Solis wrote one of his most renowned essays: *Discursos sobre los comercios de las dos Indias* (discourse regarding the trade of both Indies). The essay, which was addressed and dedicated to the Count-Duke of Olivares, at the time the favourite of Philip IV, sought to replenish the "reputation" ("greatness", "*reputación*") of both the Spanish and Portuguese Empires by fostering commerce with the East and West Indies. Although he praised the merchant-class, Duarte Gomes also endeavoured to boost the maritime strength of the Portuguese Empire. He realized that the fleets from Lisbon were a key factor in the conservation of trade and of the Portuguese Eastern Empire. He intelligently recovered the leading figure of Francisco de

Manuel[2] who had assured King Manuel I that the key assets for defence of the Indies were the fleets and not strongholds (Gomes Solis 1622, p. 74). Consequently, the sea and not dryland was the field in which European countries would compete for world domination.

Duarte gave many reasons why the Portuguese fleets were not held in high repute, as they had been before. He pointed out that timber quality for shipbuilding was a key factor in the outcomes of naval conflicts and conservation of the Portuguese Empire (Gomes Solis 1622, p. 153). In addition, Duarte Gomes provided essays and memorials he had already addressed to the King and his ministers. In one of them, written around 1612, Duarte, along with Francisco Lopez Carrasco, committed himself to building six vessels in India in 6 years for the *Carreira da India*. Ten years afterwards the author added new comments to the essay asserting, "the Portuguese mountains are depleted, there is no suitable timber" (Gomes Solis 1622, p. 200). Although such an assertion was clearly shaped by the purposes and bestowed interests of the merchant, the research conducted here certainly leads to very similar conclusions.

Based on these assertions, the goal of this article is twofold. On the one hand, it intends to investigate the exploitation of Portuguese forests for the construction and repair of Royal fleets in Portugal, paying special attention to the Lisbon shipyards and the surrounding hinterland that provided timber. On the other hand, it seeks to shed light on how certain factors hindered the Portuguese in their maritime conflicts against their enemies. The reasons for this include the overexploitation of forests, the carelessness—or inattention—of the King's ministers, a lack of ships and the ambitious foreign police headed by the Spanish Monarchy during Count-Duke of Olivares *valimiento*, or struggle for world dominance (*Monarchia Universalis*).

2 The "Hectic" Shipbuilding Years (1617–1625)

In 1609, the Spanish Monarchy and the Dutch Republic signed a twelve-year truce. During this period, they did not go to war in Europe; however, Dutch fleets threatened and attacked overseas territories, focusing especially on Portugal's Eastern Asian and Brazilian territories (Boyajian 1993, p. 158). There was no suggestion of peace between both maritime empires, only a pause that masked an actual war.

In addition, the Spanish and Portuguese empires could not afford the luxury of disrupting or even decreasing shipbuilding activity, as their territories were scattered across the world. Fleets and ships were utterly necessary to keep the Empire connected and to exercise power in a time in which stiff competition from other European contenders had increased dramatically. The "peaceful" foreign policy of the Spanish Monarchy in Northern Europe from 1609 to 1617 was partly because it

[2] First viceroy of the Portuguese Indian State.

had turned its attention to the Mediterranean Sea, more specifically to the Muslims in Northern Africa.

Consequently, 1617 turned out to be a turning point in the Spanish Monarchy's foreign policy. The rise of Baltasar de Zúñiga within the court led to a shift in the values that would orient the Spanish Monarchy in their military conflicts (González Cuerva 2012, pp. 386–394, 401–449). The idea of "reputation" (*reputación*) became more important than in prior years, and it maintained its validity during the following years up to at least 1634, which is the final year studied in this article (Elliott 1990).

This foreign policy shaped shipbuilding activity, although it was also a reciprocal interconnected process. This explains the frantic shipbuilding activity of the Spanish Monarchy during Philip III's reign, especially from 1598 to 1609 and 1617 onwards (Thompson 1976, pp. 198–200). From 1619 to 1622, the Portuguese Treasury Council contracted private individuals to construct galleons for the Indian fleets of 1619, 1620, and 1621 (Boyajian 1993, pp. 186–187). In these years, the Marquis of Alenquer, who was viceroy of Portugal, made great efforts to display Portugal's naval power (Gaillard 1982, pp. 255–298; Dadson 1991; Trapaga Monchet 2015). It eventually affected the capacity of forested areas in Portugal to supply good quality timber for shipbuilding. It led to unsustainable timber exploitation, which was more acute in some areas such as Alcaçer do Sal where, according to the *monteiro-mor* in 1622, it was difficult to find stone pine.[3]

The timber shortage affected not only Portugal, but also spread to Spanish shipbuilding activity. In the following year, Don Fernando Albia de Castro stated that he could not provide masts nor lateral planks to the Portuguese Crown because the High Sea Fleet and the ships being constructed in Guipuzcoa and Biscay required them.[4] Furthermore, private individuals were closely involved in the construction process for His Majesty's fleets. In 1621, Cristóvão Machado reached an agreement with the Portuguese Treasury Council (*Conselho da Fazenda*) to construct two galleons in Peniche, which would be deployed within the Portuguese coastal fleet (*Armada do Consulado*). Although we do not know with certainty, it is very likely that the pine timber used for this fleet probably came from Leiria's pinewoods, as was usual (Pinto 1938). In March 1622, the Portuguese governor ordered the *monteiro-mor* to extend permission to Cristóvão, by which he was allowed to cut 500 cork oak trees in the Santarém area to finish construction of the *São João* galleon. The *monteiro-mor* passed the order to Antonio Dias Montalvo, *monteiro-mor* of Santarém.[5]

Some months afterwards the ship sailed to Telha, located near Lisbon, where the construction of the *cuberta* was taking place.[6] Cristóvão Machado stated that 502

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[3] Arquivo Histórico Ultramarino (hereafter AHU), Conselho Ultramarino (hereafter CU), Reino, box 3 folder 91, September 271,622.

[4] AHU, CU, Reino, box 4, folder 6, January 121,623. Written probably from Lisbon.

[5] Biblioteca e Arquivo Histórico de Ministério de Obras Públicas (hereafter BAHMOP), Montaria-Mor do reino (hereafter MMR), nucleo 9, March 1622.

[6] AHU, CU, Reino, box 3, folder 77, August 1622.

cork oaks (*paos*) were necessary to finish the construction. Valentim Temudo confirmed the information Cristóvão Machado had pointed out and stated how the timber would be used: 250 trees for square knees (*curvas coadradas*), 150 for circular top timbers (*aposturas redondas*), 50 for beam shelves (*dormentes*), 50 for waterways (*trincanices*), and 2 trees to construct 2 *papoias*. According to the report made by the warehouse's purveyor, the *monteiro-mor* issued the order to André Dias Montalvo.[7]

The warehouse's purveyor, Francisco Rebello Rodovalho visited the ship constructed by Cristóvão along with Cristóvão Machado and officials from Lisbon's shipyard to confirm it was being built according to the terms they had agreed.[8] Workers from Lisbon shipyard checked that the keel, frames, top timbers, and internal timbers had been built according to the contract. However, some of the timber of the stern and stern planks were rotten. If there was enough material available, the construction would be finished within 2 months.

This construction activity was based on Philip IV's order that the Portuguese fleet must comprise eight galleons and two *pataches*.[9] In 1622, the construction of a galleon devoted to "Consulado" was carried out in Peniche, perhaps the aforementioned galleon *São João*.[10] Portuguese materials and ships' resources could not, however, satisfy the requirement for ships ordered by Philip IV; therefore, don Valentim Temudo was entrusted to acquire two galleons that had been constructed in Biscay.[11] This was not the first time the Portuguese Government purchased ships in the North of Spain as, in 1600, six were acquired (Salgado 2016, p. 48).

As usual, the Portuguese *Carreira da India* demanded ships. It was expected to deliver two ships to India in 1623, so the Portuguese Treasury Council together with Roque da Silveira, purveyor of the King's warehouses, determined the required timber. Stone and maritime pine were cut for planking, stern planks, and doublings. In addition, Roque da Silveira estimated that 657 cork oak trees were needed for fore and aft mast partners, tiller arms of rudders, big planks for fore top' dawnhauls, capstans, weatherdeck's and *reves* knees, deck-support knees, waterways and 100 trees for *apostarios* (perhaps *apostiças* or *aposturas*).[12] The Portuguese fleet would be composed of four galleons, two *urcas*, two *navios*, and two *pataches* amounting to around 3413 tonnes (Mauro 1983, p. 41).

In December 1622, Roque da Silveira listed in two reports the required timber from cork oaks and pines to construct two carracks for the 1624 Cape route. In all this comprised 3720 *madeiras mansas* (probably stone pines) for wales, two castles, deck beams (*meias latas*), and other ship components and 240 trees for stern planks. In addition, 4249 cork oaks were expected to be felled to construct a wide range of

[7] BAHMOP, MMR, nucleo 9, August 1622.

[8] AHU, CU, Reino, box 4, folder 21.

[9] AHU, CU, Reino, box 4, folder 51.

[10] AHU, CU, Reino, box 3, folder 63.

[11] AHU, CU, Reino, box 4, folder 69. December 1623.

[12] BAHMOP, MMR, nucleo 9, November 1622.

ship components. Among others, 700 trees for upper futtocks (*aposturas*), 820 for weather deck's knees, 280 for deck-support knees, 260 for clamps or beam shelves, 200 for lower clamps, 260 for waterways, 200 for channels.[13] Some weeks afterwards another 1000 stone pines were to be cut for repairs and wales for Indian-going ships.[14]

It should be noted that the wood was not only deployed to build new ships, but also to repair both those belonging to the Portuguese Crown fleet and those arriving from India, and sometimes even for Spanish ships based in Lisbon. In January 1623, the governors compelled the *monteiro-mor* to give permission to cut pine trees in the Ribatejo area to repair the ships of the Portuguese Crown. Roque da Silveira listed the necessary stone pine timber, which would be cut in Benavente and Alcacer do Sal during the waning moon of January.[15]

In 1623, Cristóvao Machado committed himself again to building two galleons in Peniche of 500 tons each. They were probably built using timbers from Leiria, Peniche, and the surrounding areas. The ships were constructed according to the measurements provided by Valentim Temudo and were fortified afterwards. The galleons *São João* and *São Antonio* eventually surpassed the agreed 500 tonnes.[16]

Once the military conflict of the summer of 1623 came to a halt, it was time to arrange and outfit fleets for the forthcoming campaign. The Indian shipping carracks had had issues reaching Lisbon safely, as pirates had looted the Portuguese coast. Both the courts of Lisbon and Madrid realized it was indispensable to reinforce the fleets to be able to successfully face the challenge of their enemies.

The Portuguese forested areas were put under pressure as a result of the fact that Lisbon's shipyards required further trees to complete the construction of two vessels bound for India. In October, Vasco Fernandes Cesar listed the indispensable amount of cork timber, which reached 1218 trees, for the construction of capstans, intercostal beams, clamps, waterways, deck-support beans, beak knees, fore and aft mast partners, mast steps, and big planks for various purposes. In addition, the governors of Portugal delivered a decree to the *monteiro-mor*, by which he was committed to cutting down another 272 trees in Mugé for the two relief galleons.[17]

In September, the Portuguese government accepted Fernão Alvares and Baltasar da Maia's bid to construct the hull of two galleons and two small ships—perhaps *pataches*—in Porto. This information is highly valuable as it is one of the few contracts (*asientos*) we have found in Portuguese archives that includes orders by the Portuguese government for the construction of ships in Portugal (Mauro 1983, pp. 49–51).[18] The contract is divided into 16 clauses that specify the rights and duties of the contracting parties. The Portuguese government listed in detail the

[13] BAHMOP, MMR, nucleo 9, December 1622.

[14] BAHMOP, MMR, nucleo 9, January 1623.

[15] BAHMOP, MMR, nucleo 9, January 1623.

[16] AHU, CU, Reino, box 4a, folder 12, February 1624.

[17] BAHMOB, MMR, nucleo 9, October 1623.

[18] The following lines are based on AH, CU, Reino, box 4a, folder 12.

measurements of four ships, the delivery date, and the funding the contractors would receive in turn. The two galleons would weigh around 500–540 tonnes and the two light ships 150 tonnes, as the Royal Treasury was obliged to contribute 13,824,000 *reis* for both the galleons' hulk and 2.7 million for the lighter ships. The Crown would not only request that the Porto's bishopric allows trees to be cut but would also issue orders to fell one thousand maritime pines in Leiria and Mondego pinewoods for lateral planking and *latas* (half deck beams?). Torre de Moncorvo and the surrounding areas would supply 200 quintals of linen and hemp and 100 quintals of tow (*estopa*) for the construction. According to Fredéric Mauro, the Spanish government pointed out that unlike the Tagus area, this part of Portugal still had plenty of timber for shipbuilding (Mauro 1983, pp. 49–50).

In addition, Baltasar Gonzales and Valentim Temudo committed themselves to building a carrack each in Lisbon, with the condition that they would be helped in cutting the trees that would be deployed in the construction.[19] The trees would be chopped according to the measurements (*vitolas* in Portuguese); therefore, the trees were cut and the wood was used as timber according to the measurements stated by the builder.[20]

1624 was not a year of respite for Portuguese forests; on the contrary, "frenetic" timber exploitation continued to be the trend. During the waning moon of December 1623 and January 1624 at least 9500 trees were cut down in the areas of Santarém—cork oak, Coruche—stone pine, and Leiria—maritime pine. The timber was used for the construction of two ocean-bound three-deck ships and, to a lesser extent, for repairs.[21] Perhaps these were the two ships Gil Fernandes Aires had agreed to build.[22] The purveyor of the warehouses was ordered to construct two new ships, probably in Lisbon, with the measurements the King had ordered in another dispatch. Therefore, the Crown sought to monitor shipbuilding activity more closely, a pattern that spread throughout the Monarchy (Vasconcellos 1960, pp. 25–49; Varela Marcos 1988, pp. 121–136; Wing 2015, p. 152). The ships would measure 20 or 21 *rumos* instead of the traditional 19 they had measured before.[23] Castro (2003, p. 10, 2005, pp. 189–192) considers these measurement systems in detail.

However, in May there was not enough suitable timber in Lisbon shipyards to continue constructing the two carracks for Cape shipping, because the inhabitants of Pederneira were reluctant to carry the timber from Pederneira to Lisbon.[24] Furthermore, Lisbon's shipyard workers could not fulfil all of the required tasks, as

[19] BA, Ms. 51-VI-28, f. 57r-v.

[20] This document stated the purveyor of the King's warehouse had the task of watching personally the gauges (*bitolas*) for the 3-decks being constructed, as the timbers would be cut according to them, February 131,623.

[21] AHU, CU, Reino, box 4a, folder 10, BAHMOP, MMR, nucleo 9, January 1624.

[22] The accepted agreement was delivered from Madrid in December 1623, AHU, CU, Reino, box 4a, folder 68.

[23] Biblioteca de Ajuda (hereafter BA), Manuscripts (hereafter Ms.), 51-VI-28, f. 61v.

[24] AHU, CU, Reino, box 4a, folder 27.

it was necessary to gather carpenters and caulkers from Porto and Coimbra areas.[25] This would cause issues, as in Porto the construction of two *pataches* and some galleons was taking place under the supervision of the "Chancellor" of Porto.[26] Measurements were decided in Lisbon and delivered afterwards to Porto. In other document is asserted two small ships of 150 tonnes each were being constructed in Porto at 2,700,000 *reis* each. They might have been the above quoted *pataches*.[27] By March 1625 the construction of galleon *São Antonio*'s hull was nearly finished, whereas *Nossa Senhora de Batalha* was behind schedule due to a lack of timber.[28] Each galleon's hull would cost around seven million *reis*, weighing 500–540 tonnes.[29] To protect them, the Crown ordered that some galleons be transferred from Bizcay and escorted to Lisbon.[30] A milestone that was quite fundamental for finishing the ships was the construction of the beams deployed to launch them into the river. In August 1624, Vasco Fernandes Cesar stated that 450 cork oak (or Portuguese oak) trees were necessary, perhaps to launch the ships and to construct their stern grids.[31] This is one of the few references we found related to the use of oak in South Portugal, as cork trees along with stone and maritime pines were by far the most frequent tree species in Lisbon's shipyard.

Furthermore, the Crown reached an agreement with Feliciano Monteiro and Duarte Correa to build one ship to sail to India in 1626, which would require cork oaks and pines for its construction.[32] In 1625 a Spanish-Portuguese combined fleet conquered Bahía de Todos os Santos, a milestone in the maritime conflict against the Dutch Republic. This did not result in a decrease in timber use because, in the following years, the Spanish Monarchy's struggle to maintain maritime power took a tremendous toll on Portuguese forests.

Consequently, Portuguese shipyards demanded further timber to construct, in this particular case, two new carracks with three decks each. The amount of cork oak required amounted to 5403 trees, and possibly an additional 1250 trees for two *pataches* and 1000 trees to repair another ship.[33] Despite all these efforts, Portugal could not struggle alone against its competitors and often required the support of the Castilian Crown. In 1623 it appears that the Castilian Crown provided four galleons and a large amount of funding to the Portuguese crown.[34] In 1628 and 1629, the Castilian Crown lent numerous ships to the Portuguese fleets again (Salgado 2016, p. 49). The shortage of funds was

[25] AHU, CU, Reino, box 4a, folder 28. May 1624.

[26] AHU, CU, Reino, box 4a folder 29; box 5 folders 1 and 8.

[27] AHU, CU, Reino, box 5, folder 13.
. BA, Ms. 51-VI-28, f. 78v.

[28] AHU, CU, Reino, box 5, folder 11. February 1625, letter of Baltesar Gonçalves shipwright delivered from Lisbon to Porto.

[29] AHU, CU, Reino, box 5, folder 13.

[30] BNE, Ms. 2.846, f. 185r.

[31] BAHMOP, MMR, nucleo 9, August 1624.

[32] AHU, CU, Reino, box 5, folder 22. April 1625.

[33] BAHMOP, MMR, nucleo 9, December 1624.

[34] Biblioteca Nacional de España (hereafter BNE), Manuscritos (hereafter Ms.), 2.845, f. 27r-v.

a constant issue in the period studied here, and it hindered the construction of ships in Lisbon and Porto.[35] In 1625, Muslim pirates sailed to the Portuguese coast and plundered from Algarve to the Tagus River mouth without hardly any opposition from Portuguese fleets.[36] Sometimes the Castilian galleys based in Lisbon were deployed to escort Portuguese fleets that came from overseas territories, whereas others were required to defend the Spanish and Portuguese coasts.[37]

"Ship starvation", in other words a shortage of ships, affected private owners, who were sometimes forced to sell or lend their ships to the Crown. In 1624, for instance, Vasco Fernandes Cesar went to Setúbal to find out whether there were any private ships available for the Portuguese fleet. Although there were three seaworthy vessels, the Portuguese Crown could not use them because the Castilian Crown had already seized them. As a result, Fernandes Cesar was encouraged to deal with the owner of the *urca Leao Rosso* to reduce the agreed price of 3.6 million *reis*.[38] In the following year, the Portuguese Treasury Council enquired about the cost of repairing and outfitting the carrack *São Tomé*.[39] In 1625, Antonio Fernandes Paes travelled from Lisbon across Spain to purchase a galleon suitable for the Portuguese *Carreira da India*.[40]

Moreover, the Monarchy eventually gave permission to acquire Dutch ships as long they were purchased indirectly. Diogo Tristão de Mendoza was authorized to buy up to ten Dutch vessels to outfit the sixteen-ship squadron he had offered to relieve Brazil.[41] In the following years, military conflict enhanced pressures on the Spanish Monarchy, which again affected the forested areas of Portugal, as Portugal was overrun by the thriving Dutch fleets, an element that affected the trade between India and Portugal (Boyajian 1993, pp. 202–208). The following section examines how the maritime struggle affected the forests of Portugal.

3 Timber and Shipbuilding for Maritime Struggle (1626–1634)

In January 1626 governors of Portugal, in accordance with Philip IV's dispatches,[42] ordered that pine and cork oak timber be carried to Seixal, where the construction of two galleons was going to take place.[43] As a result, tree felling spread across

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[35] This issue is constantly emphasized in the archival sources, BNE, Ms. 2.845, ff. 145r-146r.

[36] BNE, Ms. 2.846, f. 180r, February 1625.

[37] BNE, Ms. 2.846, f. 183r.

[38] AHU, CU, Reino, box 4a, folder 27. May 1624, Portuguese Treasury Council.

[39] AHU, CU, Reino, box 5, folder 33. June 5, 1625.

[40] AHU, CU, Reino, box 5, folder 43.

[41] Archivo General de Simancas (hereafter AGS), Secretarías Provinciales (hereafter SSP), libro (hereafter lib.), 1.520, f. 122v or 123v, November 1626.

[42] AGS, SSP, lib. 1.520, f. 6r, Barbastro January 311,626. This year the King would deliver 200.000 *cruzados* to outfit the fleet based in Lisbon.

[43] AHU, CU, Reino, box 5a, folder 1,

Portugal to such a degree that even the Portuguese authorities began to be concerned, as that year they aimed to build at least two galleons for the Portuguese Crown and another two carracks for the *Carreira da India*. This boosted the demand for timber, because royal charters were issued to the *monteiro-mor* to permit the cutting of almost 10,000 cork oak trees in the Santarem area, 5480 of them to construct the India-bound vessels and 4000 for two galleons. This was an extraordinary quantity, especially taking into account the fact that pine trees were not listed yet, as they were estimated to be around 1500 trees. In addition, Portuguese ministers postponed the felling of another 1000 cork oak trees until August, which the government demanded in order to give some respite to the forests.[44] Altogether, more than 12,500 trees were required, an extraordinarily high quantity that clearly must have had an impact on the forested areas of Portugal.

In 1626 Agostinho Diaz was in charge of the so-called figure of the *feitor*, who was responsible for seasoning pine timber in Melides for the construction of two galleons for the 1627 *Carreira da India*. The Portuguese Treasury Council relied on someone to season the timber where the trees were felled. The following year, Manoel Gomes Pereira was appointed to cut and season a considerable number of pine trees for the construction of two galleons for the Consulado's fleet in the surrounding areas of Pederneira. Did the Portuguese Treasury Council set up a new "legal figure" to establish better monitoring over the timber supplying process during Philip IV's reign? This question should certainly be addressed in future research in this area.

Manoel Gomes Pereira faced uncooperative local inhabitants, whom he needed to employ to carry the wood to Pederneira, because the Crown owed them large sums of money from previous assignments. In addition, he was running out of funds to saw and curve (*lavrar* in Portuguese) the wood before loading in Pederneira to send out to Lisbon.[45] Meanwhile, Simão Alvares da Costa cut trees in Batalha during the February's waning moon to supply timber for shipbuilding.[46] This timber was probably destined for Porto, where the construction of at least two galleons was taking place, one of them to replace the carrack *Chagas* that had wrecked in Coruña in the *Carreira da India*.[47]

Furthermore, private lands were also used to supply resources for the Portuguese Empire, as Tristão de Mendoza Furtado requested permission to cut 200 cork oaks for shipbuilding.[48] The King's ministers based in Madrid were aware of the different procedures used to ensure the ongoing flow of timber, as Philip IV ordered that all of the wood be carried to Lisbon to construct the two carracks that would sail to

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44 BAHMOP, MMR 9, January 1626.

45 AHU, CU, Reino, box 5a, folders 4, 6.

46 AHU, CU, Reino, box 5a, folder 6. The trees were felled in February's waning moon.

47 AGS, SSP, lib. 1.520, f. 27r, March 131,626, Monzón.

48 AHU, CU, Reino, box 5a, folder 8.

India the following year.[49] Such frantic activity was the result of Philip IV's order that the Portuguese Crown fleet must comprise seven galleons.[50]

In Madrid, and perhaps even in Lisbon, the ministers of Philip IV sought to restrict private involvement in the construction of ships to some extent. The Portuguese Treasury was reluctant to accept a bid of Fructuoso João in which he proposed to fulfil the carpentry work for two ships for 6500 *cruzados* each, because orders had been issued from Madrid for a clearer breakdown of the construction cost.[51] A few years after he offered again, based on Gil Fernandes experience, to provide carpentry services for two carracks for 13,500 *cruzados*.[52]

After the intense activity of 1626 that put a strain on Portuguese forest resources, 1627 was a period of relief for them, as only one reference related to timber supply for shipbuilding or repairs has been found for this year. However, we still cannot be certain that both activities diminished.[53] In the same way, Tomás de Ibio Calderón asserted in June 1627: "there is littler timber left in this Kingdom for shipbuilding because they fell and do not plant replacements" (Goodman 1997, p. 83). Philip IV authorized the export of 30,000 cartloads of wood from Galicia to Portugal to construct houses. This was not a new procedure, as in 1564, 1567, and 1584 Philip II had allowed the Marquis of Astorga to withdraw up to 54,000 cartloads of chestnut wood from his County of Santa Marta and the surrounding areas to bring it to Portugal.[54] Similarly, from at least the mid-sixteenth century, timber was imported into Lisbon from Asturias (García Oro and Romaní Martínez 1990, p. 259 and 264).

In 1628, Tomás de Ibio Calderón assessed the state of the ships based in Lisbon. A ship was being built in its shipyard that would be the flagship of the Portuguese fleet.[55] The Portuguese government issued a series of charters specifying the timber required for constructing ships. Unlike in past years, the timber required amounted to less than 1500 trees, and in addition the government diverted its attention to Obidos, a place that had remained untouched in the "hectic" shipbuilding years. Did this mean the Portuguese Treasury Council was forced to look further afield for timber? Although it is not easy to give a clear response to this question because of a lack of sources, we consider that there was, at least during this year, a slight reduction in the demand for timber from Portuguese forest resources.[56] At this time, 300 cork oak beams were requested to launch the carrack *Santissimo Sacramento* into the Tagus River.

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[49] AGS, SSP, lib. 1.520, f. 53v. In April Vasco Fernandes Cesar reported the construction state of both ships.

[50] AGS, SSP, lib. 1.520, f. 83v, July 1626.

[51] AHU, CU, Reino, box 4a, folder 27, May 291,624.

[52] AHU, CU, Reino, box 5a, folder 14, May 1626.

[53] BAHMOP, MMR, nucleo 9, January 1627.

[54] AGS, Guerra y Marina (hereafter GYM), legajo (hereafter leg.) 173, doc. 76.

[55] AGS, SSP, lib. 1.521, f. 6r, July 1628, order of Philip IV.

[56] BAHMOP, MMR, nucleo 9, October and November 1628.

In these years, a number of ministers informed Madrid that the forested areas of Portugal had been depleted so dangerously in the last few years, that if the demand for timber continued at similar rates, they would be unable to continue to provide timber sustainably. Despite such warnings, during the following years the Monarchy put its military interests above the protection of forested areas. For 1629, we only have references that indicate that the Portuguese government asked the *monteiro-mor* to permit the withdrawal of 400 beams (*vigas* in Portuguese) to construct a new carrack devoted to Cape shipping.[57]

Consequently, in order to balance out the "decline" of Lisbon's shipyards and the surrounding forested areas—although this cannot be ascertained with certainty—the Spanish Monarchy resorted to deploying other resources. In 1628, Gil de Afonseca was commissioned again to purchase as many galleons as he could to strengthen the Portuguese fleets. That year the *naveta Madre de Deus* arrived from Cochin, which had been built in India with "*angelim*" and teak timbers. It was assessed for around 8000 *cruzados*, half of the price of the ship that Gil da Fonseca had bought in Biscay.[58] It seemed he acquired a galleon in San Sebastián, located in the Basque province of Gipuzcoa, which was loaded with war equipment and delivered to Lisbon.[59] In addition, ship starvation increased during the following years and the Monarchy stretched the marketplace to Dunkirk (Flanders)[60] and even to Germany and England to protect the Brazilian territories (Cabral de Mello 2007, pp. 93–98).

In terms of naval conflict, in the decade between 1620 and 1629 in Lisbon, 67 vessels were arranged to be bound for India, an extraordinary effort that was nevertheless insufficient for catching up with the Dutch fleets. Outfitting a single carrack cost about 130,000 *cruzados*, whereas the galleons cost 74,000. James Bojayian has estimated that the overall expenditure of the decade must have surpassed 7,000,000 *cruzados* (Boyajian 1993, pp. 187–188).

However, in the ensuing year, timber starvation for maritime conflict affected Portuguese forests. The Portuguese government ordered that 8000 trees of cork oak, oak, and pine be cut for the *Carreira da India*, Portuguese and Castile fleets based in Lisbon. The new galleon that was being built in Lisbon required 4500 cork oak trees, possibly including additional pines and imported timber to have an idea of the amount of trees necessary to construct one ship. The remaining timber was used to repair ships. In 1631, the Portuguese government demanded less from the Portuguese forests (at least 3000 trees), but 1632 was a year where efforts in shipbuilding greatly increased, and it therefore deserves attention.

On November 23rd, 1632, the Portuguese government released an order to the *monteiro-mor* together with a report by Rui Correa detailing the timber required to

[57] BAHMOP, MMR, nucleo 9, Lisbon 1629.

[58] AGS, SSP, lib. 1.521, f. 6r, letter of Philip IV, Madrid 28 July 1628; f. 9v, October 1628.

[59] AGS, SSP, lib. 1.521, f. 21r-v.

[60] AGS, SSP, lib. 1.521, f. 21r, letter of Philip IV, June 11,630.

Table 9.1 Timber required for an ocean-going ship

Required timber	Ship components
3200 cork trees	Stem posts, doublings (*coisses*, here understood as *calçês*), keels, frames, first futtocks, *aposturas*, clamps or beam shelves, breasthooks, waterways, weatherdeck knees, *curvas de reves*, bilge stringers, deck-support knees, and other necessary things not detailed
Stone pine from Ribatejo area	
1000 stone pine trees	Wales, filler timbers, and *meas latas* (half deck beams)
400 trees	Stanchions
80 dozens	Lateral planks
40 dozens	*Dalcaza* planking
140	Stern planks
2	*Madres de Leme* (rudders)
4	*Asafroes*
2	Doublings
10	*Pinçoes* (here understood as *pinção*, whipstaff)
8	Doublings of top mast (*mastareo*)
200 maritime pine trees	*Armaçãos*
Maritime pine from Pederneira area	
140 dozen	Deck planks
140 dozen	Ceiling planks
1.000 trees	Deck beams, bilge stringers, carling
6	*Asafroes*
12 tabuas	Channels
24	*Apostiças* (*aposturas*?, if so top timbers)
6 trees	Pumps
6	*Asafrões mansos*

Source: BAHMOP, MMR, nucleo 9, November 191,632

construct a new galleon.[61] Unfortunately there is no mention either of the measurements of the ship nor the decks; therefore, it is not possible to figure out how much timber was required for each tonne. Table 9.1 shows that cork trees, maritime, and stone pines were needed to construct it. Cork timber and stone pine were obtained from the Ribatejo area close to the Tagus River, whereas maritime pine would come from Pederneira area (perhaps Leiria).

[61] In 1633, Bartolomeu Alvares, master carpenter of Lisbon shipyards, constructed the carrack *Nossa Senhora da Oliveira* that sailed to India in the next year. Perhaps it was the ship aforementioned. In 1634, he was constructing the carrack *Santa Catherina*. AHU, CU, Reino, box 6, folder 34.

Consequently, the construction of a single galleon, probably in Lisbon, in theory required that 6000 trees be cut. António Arala Pinto stated that in order to build 1200 tonnes of ship around 6250 trees were required (Pinto 1938, vol. 1, p. 147). According to John Richards throughout the early modern age the English Royal Navy consumed around 4200 to 5600 cubic metres of timber for the construction of a great warship with a capacity of 2000 tons, which required "several thousand mature trees" (Richards 2001, 224). Similarly, it has been estimated that a Spanish eighteenth-century warship consumed at least 4000 trees (Crespo Solana 2016, p. 7).

It is interesting that the Portuguese government emphasized that trees had to be felled close to the Tagus River. This point was again stressed in 1634,[62] but trees were in fact cut far from the rivers, which was a common way for timber to be transported affordably. This was another environmental footprint of the hectic shipbuilding activity that the Portuguese Monarchy had carried out since at least the onset of the seventeenth century. Timber shortages were not only caused by "ordinary" or common constructions and repairs, but also by unexpected or "extraordinary" commissions that arose because of maritime conflict.

4 Extraordinary Commissions to Keep the Monarchy Afloat

In this section, we aim to examine the way the Spanish Monarchy handled unforeseen situations that arose as a result of maritime conflict. We provide some insights into the actions of the Monarchy in 1628 and 1631 to ensure Philip IV's dominance in Eastern India and Brazil, territories that belonged to the Portuguese Crown.

In 1628, the Marquis of Castel-Rodrigo was acknowledged co-governor of the King and given the power of rejecting any interference by ministers in this role, including the governors themselves. He would count on the support of Simão Suares de Carvalho and Diogo Suares, clerk of the Portuguese's Treasury. His stay in Lisbon was extended to 1630, as he was in charge of outfitting the fleets that would sail to India and Brazil.[63] Consequently, throughout this period, Portuguese ministers were not entrusted to handle all of the demands coming from the King's fleets. Furthermore, workers in Lisbon were often overworked, so carpenters and caulkers were brought in from Porto to repair the galleons that would be delivered to India the ensuing year.[64]

In 1630 the King assigned Rui Correa Silva to acquire ships and war components in the North of Spain for the Portuguese fleets. He would ratify Domingo Gil da Fonseca's actions according to the instructions he had received, whereas anything done separate to these instructions would be declared void.[65] He was allowed to

[62] BAHMOP, MMR, nucleo 9, November 1634.

[63] AGS, SSP, lib. 1.521, ff. 7r-8r, 19v, 20v. Madrid, August 1628.

[64] AGS, SSP, lib. 1.521, f. 63r.

[65] Gil Fernandes da Fonseca acquired one galleon according to the King's orders to sail to Bahia.

check and buy any ships being constructed in Biscay. The galleons would reach more than 500 tonnes and would be delivered from Biscay with all the components (including the rigging). Because he was not a specialist in shipbuilding matters, Manuel Fernandes, who at that time was a carpenter and shipwright in Lisbon, would go along with.[66]

The maritime conflict against the Dutch Republic concerned Philip IV and Count-Duke of Olivares to such extent that Philip IV ordered Olivares in 1631 to head up a Committee. He would gather together the Duke of Villahermosa, Manuel de Vasconcelos, and Malaga's bishop with the purpose of outfitting a fleet to expel the Dutch from Brazil (AGS, SSP, book 1477, f. 1r).[67] In the sessions that followed, the Committee sought to establish a Committee of Treasury and Fleets in Lisbon to handle funding and all matters related to the fleet. The Count of Castelnovo was entrusted to perform this with the aid of Tomás de Ibio Calderón.[68]

In addition, the King ordered him to arrange a fleet of six ships to escort the *Carreira da India* carracks. Once the Count reached Lisbon, he realized the difficulty of conducting the task assigned by the King; therefore, he requested broader powers to fulfil his commitment as the Marquis of Castel-Rodrigo had done.[69] Furthermore, Rui Correa da Silva was appointed purveyor of the King's warehouses in Lisbon, despite the fact that this office was already held by someone else.[70] They arrived in Lisbon and began to outfit the fleet soon after.

However, the understanding of the situation in Madrid was very different from in Lisbon. In Madrid, the Ministers believed it was plausible to gather a squadron of six seaworthy galleons within 2 months. In Lisbon, the reality was slightly different. Castelnovo was forced to use all his skills and abilities to gather together the galleons. The fleet would be composed of galleons and carracks belonging to the Portuguese Crown, either acquired abroad or constructed in Portugal, two galleons purchased from Gaspar Brito Freire, and a galleon purchased by Rui Correa Lucas.[71]

To recover Brazil from the Dutch, the galleons *Santo António*, *Nossa Senhora da Batalha,* and *São João Bautista* were repaired in Lisbon. Lastly, four galleons were sent from Biscay to Lisbon, which demonstrated the inability of the Portuguese Crown to continue struggling without the aid of the Castilian Crown.[72] It seemed that the relief fleet would be eventually composed of 40 ships, as don Fernando Albia de Castro was committed to importing a range of war-materials to outfit 40

[66] AGS, SSP, lib. 1.521, ff. 124r-127r, Lisbon June 61,630, instruction issued by Marquis of Castel-Rodrigo.

[67] AGS, SSP, lib. 1.477, f. 1r.

[68] AGS, SSP, lib. 1.477, ff. 8r-12v, Madrid, June 1631.

[69] AGS, SSP, lib. 1.477, ff. 15v-17v.

[70] AGS, SSP, lib. 1.477, f. 31v.

[71] AGS, SSP, lib. 1.477 ff. 22r-29r, deliveries of the Committee based in Lisbon, July 12, 21, and 31. Some days afterwards Domingo Gil replaced Rui Correa, *Ibídem*, ff. 35v-36r.

[72] AGS, SSP, lib. 1.477, ff. 44v-45r.

galleons from wherever was necessary. Amidst other items, 7500 lateral planks of Flanders pine and 300 masts (*entenas*) were listed.[73]

But timber did not only come from abroad, but Portuguese forested areas were also put under pressure to cover growing demand. The Marquis of Castel-Rodrigo gave Francisco Coutinho the authority to seize whatever trolleys and carts he needed to carry timber from the forests to the Tagus River, through which it would be transported to the shipyards in Lisbon.[74]

However, this was not the greatest effort made by Count-Duke of Olivares to face the Dutch threat in Portuguese overseas territories. The establishment of the General Trade Company in Lisbon deserves particular attention here, both as a form of opposition to the Dutch in Lisbon and as a way to strengthen trade between Portugal and Portuguese India (Disney 1978, 71–135). Olivares sought to engage private merchants, although he did not manage to do so. The Monarchy handed over some carracks and materials to the Company, some of which were constructed in Portugal using Portuguese species. When the Company was established, only two of the five ships given were based in Portuguese waters: *Nossa Senora de Bom Despacho* and *São Gonzalo*. The remaining ships were already sailing to and from India: *Bom Jesus de Monte Calvário*, *Nossa Senhora de Rosário,* and the aforementioned galleon *Batalha* (Disney 1978, p. 85). The Committee's board members were bound to the Crown. The Count of Linhares was appointed as the new viceroy of India; therefore, the Monarchy did try to turn the situation around. In his instructions, Linhares received the order of setting up the Committee in India to which was entrusted, amidst other tasks, the construction, repairing, and outfitting of the vessels (Disney 1978, 85–94; Boyajian 1993, p. 192–194).

In 1629, the Company launched the carracks *São Gonçalo*, the *Nossa Senhora de Bom Despacho*, and the *Santissísimo Sacramento,* which served as *capitana* (flag ship). They sailed alongside six galleons outfitted to escort them and transport the new viceroy, Linhares. The three carracks and four of six galleons reached Goa safely in October 1629. This accomplishment was not followed by equal or similar efforts, as the following year only the carracks *Santo Ignácio de Loyola* and the *Bom Jesús de Monte Calvário* were arranged and delivered to India (Boyajian 1993, 197–198; Disney 1978, p. 112). In December 1631, the King ordered that the following year the fleet would be composed of four ships, instead of the three he had initially stated.[75] The King handed over some ships to the General Trade Company, such as the carrack *Rosario*.[76] Around the summer of 1632 the construction of a four-deck galleon was taking place in Lisbon that would be included within the General Trade Company.[77] From 1631 to 1633, less ships sailed to India than had been ordered in Madrid, despite the fact that the Committee purchased some ships,

73 AGS, SSP, lib. 1.521, ff. 25r-26r.

74 AGS, SSP, lib. 1.521, f. 40r.

75 AGS, SSP, lib. 1.526, f. 1r, Madrid, December 51,631.

76 AGS, SSP, lib. 1.526, f. 2r, February 181,632.

77 AGS, SSP, lib. 1.526, ff. 7v-8r, August 291,632.

such as *São Felipe* for 10,000 *cruzados* (Disney 1978, pp. 112–118).[78] The 1630s' turned out to be a decade of disasters for the Portuguese Empire in India. In a similar way, Magdalena de Pazzis Corrales points out that 1631 was a tipping point for the Catholic Monarchy's maritime conflict, as it was unable to sustain its military effort at such a level (Pazzis Corrales 2001, 48–51).

In addition, in 1632, Philip IV asked the Portuguese government to devise a way for the Portuguese Crown to sustain 30 ships that would amount to 10,400 tonnes.[79] Clearly, he desired to go a step beyond the efforts the Kingdom had made ceaselessly since at least 1617. The relief fleet that was delivered to Brazil in 1632 was composed of 12 galleons, 12 *navios*, and six *pataches*. A total of 10,440 tonnes, which might have been the fleet mentioned above by Philip IV (Mauro 1983, p. 41). However, the Portuguese Crown did not have the capacity to fulfil this petition, and the Trade Company was disbanded. Clearly, the Monarchy's commitments were exhausting the Portuguese forests, shipyards, and funding possibilities; otherwise, the continuous need to make commissions to buy warships and ship components abroad, which are mentioned previously, cannot be explained.

Having outlined the maritime conflict and associated shipbuilding efforts, the following section focuses on the legislation issued in Madrid and Lisbon to protect the forests from 1621 to 1634, a period in which the Monarchy turned its attention towards conserving and developing Portuguese forested areas.

5 Protecting Forests, Wood, and Timber

The conservation of forests was essential to ensuring the flow of timber to Portuguese shipyards to carry on shipbuilding activity. However, this was not the only encouragement that the kings had in mind, as the forests were, among other many things, indispensable for hunting activities, covering the daily needs of their vassals, and keeping the forges in operation, where artillery and weapons were constructed.

Subsequently, the legislation issued by the Monarchy focused on timbers for shipbuilding purposes as well. Between 1621 and 1634 the concern about the conservation of forests is reflected in the spectacular increase of ordinances,[80] regulations, laws,[81] royal charters, etc. issued both in Madrid and Lisbon. This did not necessarily mean that previously they had been less concerned, because they did not deal exclusively with forests. For instance, we might ask: What happened once a tree was cut down? At this point the aim is to show the concern of the King's

[78] BA, Ms. 51-VI-28, f. 78v.

[79] BA, Ms. 51-II-25, ff. 172r-173v.

[80] For instance, AGS, SSP, lib. 1.520, f. 125r-v, Order of Philip IV, November 61,626 attached to Leiria's pinewood ordinance.

[81] For instance, in 1624 the Portuguese Government ordered the *monteiro-mor* to gather information about anyone known for cutting and burning trees without permission. BAHMOP, MMR, 8.

ministers about avoiding the loss of wood and timber during transportation, as this was likely regarded as one of the key factors that contributed further to deforestation. It is difficult to define such a controversial word. It is understood here as was defined by Andrew Goudie: "the temporary or permanent clearance of forest for agriculture or other purposes". According to this definition, if clearance does not take place, then deforestation does not occur (Goudie 2000, p. 52).

In 1628 another essay by Duarte Gomes Solis was published, which he dedicated to the Count-Duke of Olivares. On this occasion, the author applauded Olivares's decision to set up the Committee for Trade (*Junta de Comercio*) in Lisbon, which served to channel trade between Portugal and the Eastern Empire. The merchant expanded on the arguments he had already noted in the *Discurso sobre los comercios de las dos Indias*. Lisbon, its shipyards, and the King's ministers in charge of handling matters related to the management of the empire were blamed for leading the *Estado da Índia* to its "wreck". He went on to emphasize that the Portuguese forests were being depleted because of frequent wrecks, and therefore endorsed the idea of building ships in India instead of Lisbon (Gomes Solis 1628, ff. 5v-6r).

Did this mean that the Monarchy did not attempt to handle the situation efficiently? At this point another question arises related to the prior question: What was the "administrative procedure" for supplying timber for shipbuilding from Portuguese forested areas? There probably was no single approach that the Spanish Monarchy took to ensure timber flow from forests to shipyards in Portugal. However, regarding the Lisbon area, its approach can be described as follows. The King extended a decree, order, or charter through the Council of Portugal ordering that timber be provided for the construction of an undetermined number of ships.[82] The Viceroy or governors of the Kingdom passed this request through the Portuguese Treasury Council, which soon after passed it on to the Purveyor of the King's warehouses. The Purveyor oversaw obtaining information about timber required for construction and repairs. To do so he spoke to the master carpenters of Lisbon, who had first-hand knowledge. The information he collected was subsequently delivered to the Portuguese Treasury Council, which in turn delivered the information—or the dispatch—to the viceroy to be signed. The purveyor's report was attached to the Royal Decree and delivered to the *monteiro-mor*, who extended another order to local *monteiros* and *couteiros* (forest keepers). Sometimes he specified the areas where tree felling would take place, whereas other times this information was not specified.[83]

Consequently, timber conservation began with the head of the Monarchy, the King, or at least with his *alter ego* or, if not, with high-reputed ministers. Several orders and royal charters were issued through the Council of Portugal, and probably from the Council of War, which showed the efforts displayed by the whole

[82] AGS, SSP, lib. 1.520, f. 124r, November 61,626, Madrid.

[83] Many examples can be seen in BAHMOP, MMR, nucleo 9, or AHU, CU, Reino, box 5, folder 8, January 1625.

administrative system to protect forests and use them responsibly, even after the trees had been felled.

Although Duarte Gomes Solis' concerns about forests exploitation have already been mentioned, he was not the only person at the time who was aware of the importance of forestry in conserving the Empire. The King's ministers shared this concern, as did the *monteiro-mor*, who was at that time the person in charge of conserving and developing forested areas belonging to the Crown in Portugal. In 1626, he recognized that the maintenance of the Empire depended largely on caring for and maintaining trees, wood, and timber. This letter is particularly worthwhile because he had seen first-hand the condition of the Portuguese forests, as he spent large periods of time near the forests instead of in Lisbon. In this case, he was opposed to the permission given by the Council of Justice (*Desembargo do Paço*) to Vicente Freire, an inhabitant of Abrantes, to withdraw 50 or 60 beams from the Crato Priory, because there were not enough cork oak trees for shipbuilding. His rejection was based on the argument that in recent years a large amount of timber had been wasted because of carelessness and mismanagement by the ministers. In 1622, 3000 trees had been cut to construct two galleys, but they ended up being anchored in the harbours. In 1623 and 1624, he ordered to that 5000 trees be felled each year, of which 600 were left in the forests. In 1625 around 500 trees were left and lastly, in 1626, 700 trees.[84] In addition, the *monteiro-mor* did not extend the permission to Bras Telles, who intended to cultivate his lands in Lamarosa Valley, close to Santarém. Although the *monteiro-mor* argued they were necessary to supply timber for shipbuilding, the Portuguese government ordered him to extend the requested permit.[85]

The loss of timber continued to occur during subsequent years, because timber remained on Pederneira's beach during the winter without any protection against the effects of weather. What were the reasons behind this? Obviously, there was no single reason, but rather various factors. In addition to the reckless behaviour of officers, sometimes the cause was a lack of ships for transport, the constant presence of enemies on the Portuguese coast, or weather conditions that restricted the transport of timber in Pederneira to the summer months. According to master Alvaro Dias, an inhabitant of Pederneira, the forests surrounding Pederneira-Leiria were considerably depleted because a large amount of timber was lost every year.[86]

The Portuguese Treasury Council interfered in this matter, as they sought to protect and develop forested areas in Portugal, although not always with good outcomes. Several ministers were assigned to this task during the years studied here. In 1626, Agostino da Cunha delivered a letter assessing the damages António Mascarenas and others had caused to Virtudes pinewood.[87] The owners of lands within ten leagues of the Tagus River required a dispatch allowing them to cut, to

[84] AHU, CU, Reino, box 5A, folder 20, Almeirim, June 181,626.

[85] AHU, CU, Reino, box 5a, folder 35.

[86] AHU, CU, Reino, box 6, folder 33, April 1634.

[87] AHU, CU, Reino, box 5a, folder 28.

cultivate, etc. their own lands, as the Portuguese kings had priority over these areas for shipbuilding. In 1629, Rui Vaz de la Cerca, an inhabitant of Portoalegre, requested permission to cut some cork oak trees because they were so wide that they were useless and did not allow for growth.[88]

In 1634 Diogo Borges Bandera, an agent appointed by the Monarchy to cut cork oak trees in Coruche, warned that a large part of the cork oak trees devoted to the *Consulado* fleet were burnt. The cork oak trees had been cut in Coruche and other areas of the Santarem district. The Portuguese Treasury Council could not stand such activities because they went against "His Majesty interests" and Afonso Botelho, who had been purveyor in Elvas, was appointed to convey an investigation to clarify the matter.[89] The Councillors intended to find the culprits to punish them in an exemplary manner to avoid similar events. It seems this was not the first time such an event took place in Portugal.[90]

Another practice put in place by the Monarchy to protect and develop the forested areas of Portugal was to reduce lands belonging to the Crown and sell them as arable lands to private individuals with the condition that they must plant and safeguard trees for shipbuilding. These policies were conducted at least from 1627 to 1632, during which time the Crown properties were reduced, partly to fund the military conflict.[91] The "new lands" were called "*sesmarias*", and the "*sesmeiros*" were those in charge of safeguarding them. Their importance to forestry and timber supply for shipbuilding increased in the following years, reaching a point at which the Crown entrusted the conservation of the forests to them. A Committee—*Junta dos Pãos*—was set up, made up of Jerónimo de Souto and other ministers that gathered the required information. In September 1631, the King ordered the reduction of his forested areas accordingly to the information provided by doctor Jerónimo de Souto and the Portuguese Treasury Council based in Lisbon.[92] The Portuguese government was somewhat sceptical of implementing such a measure, thus the King confirmed it twice some months afterwards.[93]

Moreover, the sovereign requested information about the forested areas of Almeirim because he was interested in transferring them to private owners.[94] The *monteiro-mor* described the flatlands (*chans* or *chãos* in Portuguese) of Almeirin and the surrounding areas. The area had a width of two leagues and Philip IV's predecessors had reserved it as a *coutada*, because it was located close to the Tagus River. However, not all the lands belonged to the Crown and the King reached an agreement with local inhabitants by which they could use them for their livestock. In the north of the sierra of Sintra there was plenty of stone pine that Jeronimo Soto

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[88] AHU, CU, Reino, box 6, folder 17.

[89] AHU, CU, Reino, box 6, folder 35, September 1634.

[90] AHU, CU, Reino, box 7, folder 32, January 1635.

[91] On August 101,628, the Marquis of Castel-Rodrigo was permitted to sell these properties belonging to the Crown to sustain the military conflict in India. AGS, SSP, lib. 1.521, ff. 6v-7r, 11r-v; BA, Ms. 51-X-3, ff. 27r-29r.

[92] BA, Ms. 51-X-3, f. 27v.

[93] BA, Ms. 51-X-3, ff. 27v-29r. It was repeated again in July 1632, f. 30r-v.

[94] BA, Ms. 51-X-3, ff. 23v-24r, July 111,632.

had planted.[95] The Crown argued that this action was performed because there was a lack of timber for shipbuilding, and the wood was easy to transport due to its proximity to the Tagus River. To strengthen his letter the *monteiro-mor* attached a map illustrating all the information he had provided. He was utterly opposed to transforming these lands into *sesmeria*.

This decision was resisted by other officers, who claimed that the *couteiros* and *monteiros* looked after the Kings' interests better than the municipalities and *sesmeiros*. The latter were regarded as enemies of the Crown, at the same level as farmers and fires. During 1632 and 1633 fires had spread through the forested areas due to the carelessness of the municipal authorities; therefore, it was necessary to recover jurisdiction over the forested areas for the *couteiros* and *monteiros*.[96]

Consequently, the Crown shifted the jurisdiction of the forested areas to other Ministers to maintain better control. The decision was probably taken in both the Madrid and Lisbon courts, although the former had the last word. This measure significantly disrupted the traditional order that had been upheld in Portuguese forestry for a long time. Multiple explanations can be given that reflected the incapacity of the Monarchy to both ensure timber supply for shipbuilding and halt growing deforestation in Portugal. The latter was caused by various factors, such as shipbuilding activity, the carelessness of ministers, particular interests, or an insufficient number of people in charge of protecting forested areas. The Monarchy was concerned not only with the quantity of the forests, but also with the quality of the timbers used in shipbuilding.

6 Assessing Portuguese Timber Quality for Shipbuilding

In 1624–1625, Madrid was concerned about the quality and measurements of timber used in Portugal for shipbuilding. The use of high-quality timber was essential because it made a huge difference in Portugal's performance in military conflicts. The research conducted by Filipe Castro concludes that the ships constructed in Portugal at the beginning of the seventeenth century for Cape shipping were made of small and thin timbers. The local tree species seemed to be less competitive than foreign species, especially those of Northern Europe, so the Monarchy sought to reverse this situation.

In 1624, mule drivers came from La Sierra de Cuenca carrying pinecones to be planted in Portugal, in the forested areas (*coutadas*) belonging to the Crown. In April, the *monteiro-mor*, along with the local *monteiros* and local inhabitants with expertise in trees, planted 10 *sacas* (sacks/bags?) in Salvaterra. In Leiria, the chief magister, along with Manoel de Brito e Meneses, planted pinecones in the King's pinewoods. In Almeirim, Jerónimo de Souto oversaw planting, whereas Agostinho da Cunha de Vilasboas was responsible for the pinewoods of Azambuja and Virtudes.

[95] See below for further information about this process.

[96] BA, Ms. 51-VI-3, ff. 297r-300r, May 1634.

Even in Sintra, a place where forested areas were not devoted to shipbuilding, the chief magister Gaspar Cardoso carried out similar measures.[97]

Furthermore, trees cut down in Leiria and Pederneira were cut afterwards into smaller pieces, because they were larger than the vessels that would transport them from Pederneira to Lisbon. The King ordered the Portuguese Treasury Council to determine whether it was convenient to construct larger caravels to ease the transportation of trees in a single piece (Mauro 1983, p. 50).[98] The ensuing year, Manuel Gomes de Pederneira, at that time timber factor for the King, reached an agreement with two shipmasters of Pederneira. They would construct two caravels to carry timber for four years from the surrounding areas of Pederneira.[99] It seemed they were constructed because the Spanish officer Tomás Ibio Calderón seized two caravels that came from Pederneira that carried timber for shipbuilding to deploy them for Castile's fleet based in Lisbon.[100]

This is perhaps why the research conducted in the field of nautical archaeology showed that there was such a shortage of timber deployed at the beginning of the seventeenth century—that it had been necessary to assemble some of the pieces to make the larger ship components. In addition, in 1634 Tomás Ibio Calderon added another reason, which in our opinion seems to be more relevant in terms of explaining one of the disadvantages of Portuguese forests in comparison with, for instance, the north of Spain. It was connected with the aforementioned overexploitation, which did not allow trees to grow large enough to be suitable for shipbuilding, as Manuel Galego, a shipwright in Lisbon, pointed out in 1628: "the cork oak timbers that are felled today are not long enough to be fastened and connected together as they were in the past…and what is available today is so little that in a few years there will be no more timber to build *naus*" (Castro 2005, p. 155). In the years after, Spanish and Portuguese Ministers carried on cutting trees in Portugal without respecting their natural cycle of growth.

In 1634 the Dutch conquered Paraiba, which reflected the inability of the Spanish Monarchy to continue fighting successfully against the Dutch fleets. This year could be seen as a tipping point for Lisbon shipyards and Portuguese forests. As was done every year around December, the purveyor of the King's warehouses in Lisbon, Vasco Fernándes Cesar, recalled the importance of cutting trees both for constructing and repairing ships. Most of Philip IV's ministers endorsed Vasco Fernandez Cesar's opinion, but not all of them. Tomás de Ibio Calderón, who was probably Olivares' most trusted minister in Lisbon regarding maritime matters, highlighted the inconvenience of constructing ships in Lisbon.

He argued that there were two reasons to not construct *naos* in the shipyards of Lisbon. Firstly, the caulkers and carpenters of the shipyard were not hard workers.

[97] BA, Ms. 51-VI-28, f. 62r-v.

[98] AHU, CU, Reino, box 5 folder 31.

[99] AHU, CU, Reino, box 5a, folder 10. The masters were Cristóvão de Almeida o'Velho, Pedro Ruiz, João Domingues, Cristóvão Dalela, Pêro Fernandes Cascão, Fernão Martins, Pêro do Ruis Machado, António Machado, March 291,626.

[100] AHU, CU, Reino, box 5a, folder 21.

Secondly, the quality of Portuguese timber was not good enough, as it was very short, and it demanded a huge investment to assemble the pieces.

As a result, he proposed the construction of smaller vessels for the Cape shipping using Galician oak (*roble gallego*), as this timber was sturdier and the construction would be more economic.

We cannot be sure if the policymakers followed his recommendation. However, there are two things we know for sure. Firstly, the Count of Miranda (at that time the right hand-man of the governor of Portugal) ordered trees to be cut in Portugal for the construction of two galleons and the repair of one. This order was changed, and he ordered to timbers cut to build one carrack (*nao*), to repair another and to build galleons. For this, there would be selected pines from the pinewoods of Virtudes. Secondly, and for this essay most importantly, it is very likely that the shipyards of Lisbon were not as predominant as before. This was partly due to the quality of timber, which was better in the North of the Iberian Peninsula, and Porto was better connected to Galicia, from where Galician oak could be imported for shipbuilding purposes. The ministers argued over and considered this possibility just some weeks afterwards. They recommended that the two caravels that had been constructed to carry timber from Leiria—Pederneira—be deployed to fetch Galician oak because its timber was more suitable than pine for shipbuilding. The timber was larger and thicker; therefore, it was more appropriate for planks than Portuguese pine planks because these were shorter and narrower, forcing the king to spend time and funds for fastenings and carpenter and caulker works. In addition, the Ministers put forward another argument about Portuguese forests. It would be convenient to import timber to give respite to the King's forested areas.[101]

Consequently, the Portuguese forests were seemingly less competitive than the forests of Northern Spain for shipbuilding purposes. This led to doubts about Portuguese shipyards that caused some ministers to support the idea of moving the production centre to other shipyards like Porto or, at least, to reduce the importance of Lisbon shipyards within the overall shipbuilding effort.

7 Where Did the Timber Come From? In Which Fleets Was This Timber Used?

This chapter has highlighted several times the question of timber provenance and which fleets it was used for. Despite the wealth of the primary sources gathered here, it is not possible to accurately provide an amount of timber that was used because there are no reports—or at least I did not find any reports—for after the ships were constructed. On other occasions, the sources consist of reports and orders detailing the required timber, but these do not specify whether the trees were eventually cut or not. Therefore, Table 9.2 must be read carefully because often the collected data provide details for *before* the vessels were launched at sea.

[101] AHU, CU, Reino, box 7, folder 4, January 1635.

Table 9.2 Timber used for shipbuilding, 1621–1634

Who cut the tree/merchant	Constructor	Year	Quantity	Tree species	Provenance	Purpose
Unknown, although the report was done by Roque da Silveira		1621	6146 trees, 4546 to construct 2 ships, 1600 for repairs	Cork oak	Santarém, Abrantes	To construct two ships in Lisbon and to repair the carrack *Conceição*
André Dias Montalvo, *Monteiro-mor* of Santarem	Cristóvão Machado	1622	502 trees	Cork oak	Santarén area	To finish construction of the galleon *São João* in Peniche, and afterwards in Telha (Lisbon)
		End of 1622 (December),	1100 trees	Cork oak and pine	Ribatejo area and other undetermined areas	Ship components to construct two ships to sail to India
		December 1622 or January 1623	3960 trees	"*Madeiras mansas*" (here understood as stone pine)		Ship components to construct two ships of three decks for *Carreira da India* of 1624
		December 1622 or January 1623	4249 trees	Cork oak (perhaps pine as well, although it is difficult to state due to the document's bad condition)		To construct two three-deck ships in Lisbon for *Carreira da India* of 1624
		January 1623	450 trees	Stone pine	Benavente and Alcacer do Sal	To repair ships of the Portuguese fleet 150 trees for wales, 300 for wales and repairs

		January 1623	1000 trees	Stone pine	Alcacer do Sal and other areas	To construct and repair two ships to sail to India
		1623	460 trees	Cork oak		To construct a galley in Lisbon, finally used to construct the galleons *Santiago* and *São Filipe* that in 1624 went to India
		1623	1218 trees	Cork oak		To construct two ships of three decks that would sail to India next year
		1623	262 trees	Cork oak	In Ribatejo area in private lands	To repair the two galleons of Indian's relief
João Monteiro was the "feitor", with at least 80 lumberjacks		End of 1623, beginning 1624	6050 trees	Cork oak	Santarem	5200 to construct two three-deck galleons for 1624 or 1625 *Carreira da India*; 850 for repairs
		December 1623–January 1624	Around 3400 trees	Pine, probably maritime pine	Leiria municipality	For several components such as "*apostiças*" (*apostura*, top timbers) and "*mesas de guarnição*" (¿channel?)
		January 1624	Undetermined		Santarém area and other places	To construct two ships to sail in 1625 to India
Agostinho Diaz committed to construct 2 carracks		January 1624	500 trees	Stone pine	Coruche	To construct two ships to sail to India in 1625

(continued)

Table 9.2 (continued)

Who cut the tree/ merchant	Constructor	Year	Quantity	Tree species	Provenance	Purpose
It is difficult to assert that this one was not within the above timber		1624			Around Leiria	In 1624 Manoel Luis transported timber from Pederneira to Lisbon. 39 dozen planks (pine), 77 beams, three pumps, two channels? (*mesas de guarnição*)
		1624	450 trees	Cork oak or oak	Muge	To launch the ships and stern grids
	Baltasar de Maia and Fernão Alvares (*asentistas*)	1624	Around 1000 pine trees	Pine		To construct the hull of two galleons in Porto
		December 1624 or January 1625	5403 trees	Cork oak		To construct components for two ships of 3 decks
		1625	More than 1000 trees	Probably cork oak		To repair a ship
	The Portuguese government agreed the construction of two ships devoted to sail to India with Feliciano Monteiro and Duarte Correa	1625		Cork oak and pine	Leiria pinewood	Shipbuilding
Pedro de Viera carried tree					Probably Santarem area	He carried timber to construct "*uma barcasa*" (small ship)
		1625 and previous years	Undetermined		Coutos de Alcobaça	It seemed that during early 1620s, every year it was transported timber from the forests (coutos) de Alcobaça to Pederneira

Agostinho Diaz was in charge of the construction of pine in Melides		1626		Cork oak and pine	Some pine from Melides	It was deployed to construct two galleons above 500 tonnes in Seixal for the *Carreira da India* of 1627
Agostinho Diaz		1626	Up to 1500 trees	Pine	Alcacer do Sal's pinewood	To construct wales and stern planks for two new ships
		1626	4000 trees	Cork oak	Santarem	To construct two galleons of Portuguese fleet
Agostinho Diaz in charge of constructing two Indian-going ships		1626	5480 trees	Cork oak		To construct two ships that would sail ensuing year to India
		1626	1000 trees	Cork oak		To repair two ships
Manoel Gomes Pereira		1626		Pine	Surrounding area of Pederneira	Trees were cut during February Wanning moon for Consulado's fleet. In addition, there were constructed 2.200 deck beams (*latas de repartição*) for both Indian and Portuguese fleets
Simão Alvares da Costa		1626, February waning moon			Batalha	
Pedro Leieira was factor of cork timber		1626		Cork oak	Santarém, or surrounding areas	Trees were cut to construct two carracks for India

(continued)

Table 9.2 (continued)

Who cut the tree/ merchant	Constructor	Year	Quantity	Tree species	Provenance	Purpose
Agostinho Diaz, factor of pine trees		1626	80 trees	Stone pine	Priorato do Crato	For lateral planks
Agostinho Da Cunha		1626		Cork oak	Surrounding areas of Santarém	To construct two carracks for India
Francisco Coutinho, master of King's woods		End of 1626, beginning of 1627		Cork oak	Santarém, in Saint Francis monastery lands	To construct galleons in Seixal
		1628			Obidos	To repair Indian-going ships and the Portuguese fleet
		1628		Stone pine	Coruche	To construct wales and lateral planks for carracks and galleons
		1628	300 trees	Cork oak	Muge	To launch the carrack *Santissimo Sacramento* into Tagus river
Manoel Gomes Pereira		1628		Probably pine	Leiria's area	King's fleets
		1629	400 beams (vigas)	¿oak?	Santarem area	To construct in Lisbon the new carrack next year that would sail to India
		1630	120 trees	Cork		To finish the construction of galleon *Nossa Senhora da Batalha* next year that will sail as flagship in the Portuguese fleet

		1630	120 oaks trees, undetermined pine	Pine and oak	Muge and Almeirim	To construct and repair ships of *Carreira da India*
		1630	500 trees	Cork oak		To repair two ships belonged to the castile fleet
		1630	390 trees and undetermined for ship components	Cork oak		For the ships of *Carreira da India*
		1630	6590 trees	Cork oak		4500 to construct a four-deck carrack, 2090 to repair two carracks of three decks
		1631	3000 trees	Cork oak		To construct the carrack *Nossa Senhora da Saude* and to repair another of the *Carreira da India*
		1631	Undetermined	Cork oak		To repair the galleons of the Portuguese fleet
		1632	3200 trees	Cork oak	Areas closed to Tagus River	Ship components of the new galleon
		1632	1400 trees and undetermined for ship components	Stone pine	Ribatejo area	To construct the new galleon

(continued)

Table 9.2 (continued)

Who cut the tree/ merchant	Constructor	Year	Quantity	Tree species	Provenance	Purpose
		1632	1000 trees and undetermined for ship components	Maritime pine	Pederneira area	To construct the new galleon
		1633		Cork oak	Santarém	
		1633	Around 1000 trees	Stone pine	Alcacer do Sal	To construct two carracks
		1634		Cork oak	Benavente and surrounding areas of Muge river	To construct two ships for *Carreira da India* and to repair those of the Portuguese fleet

Sources: AGS, SSP, lib. 1.521, f. 63r, AHU, CU, Reino, box 3, folder 77; box 4a, folders 10, 12; box 5, folders 8, 53, 69; box 5a, folders 1, 4, 11, 14; box 6, folder 33; BAHMOP, MMR, nucleo 9

The table shows orders issued by the Portuguese government to the *monteiro-mor*, which gave him permission to cut the trees detailed in the attached report by the purveyor general of the warehouses. Sometimes we found the report, in other occasions we could not locate it. The table also includes other less significant references stored in the Arquivo Histórico Ultramarino and Archivo General de Simancas (orders, reports, royal decrees).

In addition, this does not include all the information quoted throughout the text because often the ships were constructed in Porto, Peniche, or other shipyards apart from Lisbon. Besides, we cannot ensure in absolute terms that all the timber described below was used only in the Lisbon shipyards. Perhaps some of it—particularly the pine from Leiria exported through Pederneira—was transported to Peniche or Porto.

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Chapter 10
Historical Documents as Sources for the Study of Shipbuilding in Spain

Ana Crespo Solana

Abstract Studies on shipbuilding in Modern Spain have been increased with new research that has complemented historical analyses and archaeological evidence. This interdisciplinary line of work is also enriched by studies carried out by a prolific school of specialists in naval engineering. Throughout a fascinating and irregular historiographical production, there have even been interesting reconstruction projects for replicas of *naos*, galleons, and frigates inspired by the classic architectural tradition of the sixteenth to eighteenth centuries. There is valuable evidence of material culture that gives us iconographic information about the proto-ships of the first oceanic voyages, such as the mysterious ex-votive figure of the *Galleon of Utrera*, which existed in the hermitage of Consolacion de Utrera in Seville until the beginning of the twentieth century. The reproduction in the Naval Museum of Madrid made by J. Guillén Tato around 1930 is seen by historians and archaeologists as a faithful portrayal of a galleon from 1540. Other experiments have led to conjectural reconstructions on several occasions, such as during the celebration of the Fifth Centennial of Discovery; the construction of the so-called Andalusian Galleon (currently a 500-ton, four-masted ship) or replicas of the *naos Victoria* (also at Expo92) and *Santa María*, which are still sailing, both built by the Nao Victoria Foundation. In the following pages I will expose the main historical sources for the study of shipubuilding.

1 Introduction

Studies on shipbuilding in Modern Spain have been increased with new research that has complemented historical analyses and archaeological evidence. This interdisciplinary line of work is also enriched by studies carried out by a prolific school of specialists in naval engineering (Achútegui Rodríguez 1996). Throughout

A. Crespo Solana (✉)
Instituto de Historia, Consejo Superior de Investigaciones Científicas (CSIC), Madrid, Spain
e-mail: ana.crespo@cchs.csic.es

A. Crespo Solana et al. (eds.), *Heritage and the Sea*,
https://doi.org/10.1007/978-3-030-86460-6_10

a fascinating and irregular historiographical production, there have even been interesting reconstruction projects for replicas of *naos*, galleons, and frigates inspired by the classic architectural tradition of the sixteenth to eighteenth centuries. Coín Cuenca has clearly explained the technical and methodological problems that the designs of these replicas create due to inconsistencies in measurements and perspectives (Coín Cuenca 2018). There is valuable evidence of material culture that gives us iconographic information about the proto-ships of the first oceanic voyages, such as the mysterious ex-votive figure of the *Galleon of Utrera*, which existed in the hermitage of Consolacion de Utrera in Seville until the beginning of the twentieth century. The reproduction in the Naval Museum of Madrid made by J. Guillén Tato around 1930 is seen by historians and archaeologists (Fernández González 2000) as a faithful portrayal of a galleon from 1540. Other experiments have led to conjectural reconstructions on several occasions, such as during the celebration of the Fifth Centennial of Discovery; the construction of the so-called Andalusian Galleon (currently a 500-ton, four-masted ship) or replicas of the *naos Victoria* (also at Expo92) and *Santa María*, which are still sailing, both built by the Nao Victoria Foundation.

Historiography delves into aspects of an unfinished debate on the origins of the different schools and architectural traditions in different regions of the Iberian Peninsula, the influence, possible or not, of other schools of shipbuilding, especially Mediterranean, Nordic-Baltic, French, English, etc.; the construction techniques used (lapstrake, flush laid Mediterranean tradition, or the floor-futtock), probable survivals of systems inherited from Antiquity, especially from the Arabs, the Vikings, or the Romans; and other aspects that are currently being dismantled or confirmed depending on new historical-archaeological evidence, as the case of the Urbieta wreck has demonstrated (Izaguirre and Valdés 1998, pp. 35–37; Rieth 2006, pp. 603–604, 607). It is obvious that the knowledge of the evolution of shipbuilding will from now on have a strongly interdisciplinary component with a predominance of scientific and exhaustive study of the wreck remains located in submerged archaeological sites. From the beginning of the first oceanic navigations the construction of a ship was done by laying the keel, and on it and according to its characteristics the payment was made to the contractor (*asentista*) or the builder. This was done in the second half of the seventeenth century but there is already evidence that it was done in Andalusia at the beginning of the sixteenth century.[1] The growth of this industry, strongly localized in port and foreland areas, conditioned the control and access to the available resources, especially wood. Along with the constant growth of local naval industries in the Iberian Peninsula, the emergence of a naval industry in America cannot be forgotten, also promoting the transfer and migration of labour, technology, and knowledge.

The comprehensive study of shipbuilding in Spain has generally been carried out in the context that gives primary importance to the socio-institutional framework of

[1] Museo Naval Madrid (hereafter MNM.) Colección Vargas Ponce, Doc. 84, 1658, 12 de marzo, San Sebastián, fols. 172–175. Contract between Cristóbal de Ayalde on behalf of Esteban de Irigoti, regarding the Ship "Santa Bárbara", and Juan Domingo de Echeverri.

fleets and navies and to the technical characteristics of shipbuilding architecture. The focus has been directed at explaining the evolution of shipyard policies, the administration of fleets and navies, the contracts and economic plans behind the shipbuilding industry, as well as the logistics of provisioning supplies, which included timber. Although abundant in general, these studies pay more attention to the eighteenth century as being the century of the most important centralization in the history of the Spanish Navy (Torres Sánchez 2013; Wing 2015; Valdez-Bubnov 2018). These works, although very important, have barely described the documentary and archaeological analysis of real ships, whose remains are located at the bottom of the sea or perhaps abandoned in coastal and intertidal areas. This perspective is essential for the study of shipbuilding in these centuries, as has been done for cases prior to the fifteenth century, and especially in the historical archaeology of the Modern Age in other countries, especially in the UK, and in a relevant way in France and the Netherlands. Underwater archaeology and historical archaeology in Spain are more developed for times prior to the Age of Discovery, as I myself have highlighted in the reasons that led me to present the ForSEAdiscovery project (Crespo Solana and Nayling 2015; Crespo Solana 2019). Furthermore, in this historiography it is also evident that, with some honourable exceptions, wood has hardly been given importance as a resource for shipbuilding (Quintero González 2004; Baudot Monroy 2012; Reichert 2016).

Undoubtedly, a pending challenge for us is to be able to compare data on wood sampled in modern wrecks with a real and adequate historical dendrochronology both in the Iberian Peninsula and in America, which does not currently exist.

For more than three centuries, a complex process of politicization of the natural resources of the forests took place, and during this process the Spanish Crown promoted the advancement of knowledge in naval technology, and the networks of agents involved in wood and ship businesses were densified. Global timber trade intensified, and the ship became a matter of state and a war business. For the sake of good scientific accuracy, it is almost impossible to understand the evolution of Hispanic shipbuilding from the sixteenth to the eighteenth centuries, dwelling only on architectural and technological criteria without understanding the parallel evolution of the organization of the navies and fleets of the *Carrera de Indias*—a topic that I develop in Chap. 3 of this book—and the control of wood for the naval industry. In the following pages, I will try to expose, from the theoretical-historical and codicological perspective, the main sources for the study of the evolution of shipbuilding in the Hispanic Monarchy.

From a codicological perspective, it is possible to carry out an analysis of manuscripts and other non-printed texts. The latter, unlike the treatises that are not very abundant, do exist in great quantity and it could even be said that unpublished texts are still located in archives and libraries. In reality, along with treatises and ordinances, other documents related to contracts and diverse documentation are also essential when studying the evolution of how shipbuilding was understood in each era and what type of historical agents participated in this technological and industrial emergence. In addition, there are other types of historical sources that can be very useful in complementing the archaeological analysis of the submerged remains and understanding why there are so many differences between theory and reality on the Iberian ship. The evolution of the construction of different typologies of ships—merchant ships, galleons, and frigates—poses questions that cannot be properly addressed before considering an important previous step. This previous step considers the ability to connect the historical dendrochronology of the Iberian Peninsula with a good and accurate catalogue of wreck timber samples. Both these tasks constitute our pending work. But how were the changes that resulted in the different phases that the construction of the Iberian ship went through reflected in the historical documentation and in the architectural treatises?

2 Documentation for the Study of Shipbuilding in Spain

In reality, the evolution of shipbuilding in the kingdoms of the Hispanic Monarchy was multidirectional and dispersed, both from the normative point of view (treatises and ordinances) and geographically. In the diverse local schools of Iberian naval technology, regional traditions of the different kingdoms were mixed, including those from Portugal. The transfer of technological knowledge between regions constituted a transfer of ideas and constructive experiences, especially between 1580 and 1640, when Portugal was one more kingdom of the Habsburg conglomerate. Furthermore, it is still a mystery how the constant transfers of knowledge took place between regions of the Mediterranean, between different areas of the Iberian Peninsula, northern and central Europe, and southern France (Cazenave de la Roche 2018).

Many of the manuscripts and printed documents existing between 1500 and 1800 refer to the debates taking place in institutions and in the Spanish Crown in relation to four main issues. First and foremost was the technological requirements of the ships to be used for the *Carrera de Indias*, as the American route was the most important economic objective of the Spanish Habsburg dynasty. In relation to this first question, two basic problems seem to have been the focus of most debates of the time: the tonnage of the region that would establish itself as the main producer of ships (with the Basque Country ahead of the Andalusian areas) and the problem of access to the Barra de Sanlúcar, layover port of the *Carrera de Indias*.

Secondly, ships had to serve in the war and commerce navies simultaneously, and it was difficult to find the perfect ship type for both purposes. This produced the long experimentation on the architecture of these ships, not always loyal to ordinances, *cédulas* and treatises and that, paradoxically, has produced many divergences between the analysed theoretical models and the archaeological remains.

Thirdly, there was no centralization of the navies in the kingdoms of the Hispanic Monarchy (in fact, it did not exist until 1704) (Crespo Solana 2017), and given the need for ships for both commercial fleets and maritime warfare, the Crown demanded or confiscated private ships that in many cases were built following different constructive formulas, carried out by contractors and master carpenters who did not follow the established laws, and this provoked a continuous debate on the reality of these ships and the correct or ideal way to build them. For this reason, and as fourth factor, the evolution of the contents of manuscripts, printed documents, and treatises on naval architecture went through various stages corresponding to different situations and demands of Spanish naval policy, the European wars and trade, especially with the American ports. This gave rise to a very diverse and heterogeneous production of ships, of multiple denominations and subject to a complex descriptive epistemology.

It can be said that the evolution of modern naval engineering was also strongly influenced by other factors: the wood demand processes; the geographical organization of shipyards, construction, and caulking areas; and the need of the Spanish crown to organize administratively the various navies and fleets of war and commerce (which I describe in Chap. 3 of this book). Logistics and spatial organization in relation to the transportation of wood resources from cutting areas to shipyards and caulking facilities was another factor to consider, as well as an important reason why the crown was always interested in forestry control (Martínez González 2013). These imperatives influenced both the timber trade and its import, as well as the construction models themselves, but also the space logistics of shipyards.

Several types of historical documentation related to shipbuilding can be highlighted. As Jan Glete has already asserted, most of the information regarding ships is still in the form of manuscripts, treatises on naval architecture, and unpublished and scattered sources (Glete 2002). The nautical treatises, the ordinances, and norms that were written from 1540 onwards, as well as other documents, such as the reports of the contractors in which the dimensions (in *codos*) and proportions that their ships had to have are used to calculate the ratios of the over overall maximum length and the keel, as well as the other ratios in relation to the keel of the boat and other timbers of the vessel. According to some authors the keel is not always the most important measurement. Some designs are based on the maximum beam, the flat of the floor, and the depth (Hormaechea et al. 2012).

I establish the following relationship by virtue of the documentary nature of the sources, but their content is still lacking a detailed analysis:

1. Codex, or treatise, printed or published or unpublished manuscripts on shipbuilding in Spain.
2. Sets of ordinances and legislative compendia.
3. Representations, proposals, and reports submitted to the boards and councils. Some of these documents were outlines of treatises that were never published or did not circulate openly. I also include here non-printed documents that were circulated at the time among agents related to the circles of shipbuilding experts. Sometimes these documents are the written mirror of rivalries and discussions between different ways of seeing and understanding the methods that should be used to build ships.
4. A last group, even more heterogeneous, would be correspondence and other documents of diverse types, exchanged by the navy and fleet personnel, contractors, and traders of naval supplies. This group is more difficult to categorize as it

is included from contracts to randomly located notarized documents about the work carried out by master carpenters and other traders in the shipbuilding industry.

Both the representations (*representaciones*) and reports and the last documentary group also offer information on the wood that was required to build a certain ship. In general, this documentation has been less studied, but it gives a lot of information about experimentation in shipyards, arsenals, and coastal or riverine locations, so that this documentation definitely requires regional analysis. It is also necessary to include in this framework the notarial documents, that in some cases have even given good results for the knowledge of the activities of master builders, carpenters, and caulkers. Although this documentation has been more marginalized in historical-archaeological studies due to its heterogeneity, it has been used in some case studies on wrecks of archaeological importance, such as the cases of the *San José* Galleon, sunk off the coast of present-day Colombia in 1708, or the Galleons of Manuel de Velasco's fleet that sank in Rande Bay in 1702 (Phillips 2010).

Unfortunately, manuals that were written and used by riverside carpenters or master carpenters of the time have not reached the present time. The art of building ships was in the hands of local constructors and many of them were migrant workers between cities and ports, illiterate in most cases. The shipbuilder and the riverside carpenter belonged to a socio-professional category to which little research has been dedicated in Spanish or Portuguese modernist historiography. It is probable that knowledge organized in a systematic way did not exist or if it did, it has not reached us. Many of these master carpenters belonged to associations of artisans that perhaps had their manuals or guides. Unfortunately, these documents do not seem to have survived. There were master carpenters and shoreline carpenters who probably belonged to some form of guild, and there were also the so-called white carpenters dedicated to the wooden construction of small parts and components of the ships, generally known as *motonería*, usually set of frames and blocks for working the lines of a ship.

I present here a summarized explanation of each of these documentary types.

The first important document is the shipbuilding treatise. The contents of these treatises, rich in descriptions and less in iconography, except in extraordinary cases such as the work of Antonio Gaztañeta, *Arte de Fabricar Reales*, contributed to the codification of knowledge about construction types. This codification allows us to get closer to how this knowledge was transmitted and how the techniques evolved throughout the different schools and traditions. However, it is necessary to highlight two issues. Firstly, and as I have said before, the shipbuilding industry originally had a local character related to the demands of commercial shipping led by groups of constructors that were almost always self-educated.

Secondly, at least for the sixteenth and seventeenth centuries, these treatises are relatively few compared to the incessant constructive work organized by the Crown and carried out from so many regional nuclei. Nor do we know, as yet, to what extent the knowledge of the master carpenters may or may not have influenced the codification of knowledge in the first official treatises. The rapid nationalization of the naval industry from the first decades of the Age of Discoveries and the political focus on the specific instrument of naval power that was the ship does not seem, however, to have much influence on the creation of an official *tratadística*, a treatise writing tradition. The work of Alonso de Chaves, "*Espejo de Navegantes*", written around 1537, although it did not appear edited until 1895 by Cesáreo Fernández Duro, was a treatise on the ocean routes known at the time and written by a pilot and manufacturer of navigation instruments, but it does not mention shipbuilding (Aguiar Aguilar 2014). The work of the Portuguese Fernando de Oliveira, "*O Livro da Fábrica das Naus*",[2] published around 1580, was one of the first Iberian shipbuilding treatises, almost contemporary with that of Escalante de Mendoza (1575), but still it was written after the decrees, *cédulas*, ordinances, contracts, and "*acostamientos*" that were produced in the Court of the Crown of Castile since the beginning of the debates on the organization of the navies and fleets for maritime traffic with America. However, some of the regulations that some of the Castilian writers and memorialists would accept followed the "Three to One" rule explained by Oliveira. The "Three to One" norm came from an ancient and medieval tradition, and it seems it was the norm in the proportion of sailboats from the second half of the sixteenth century in both the Mediterranean and the Atlantic (Hormaechea 2017).

When these treatises were written, there was already an ancient and long oral and unwritten tradition of construction in local economies that had arisen under the protection of the local and port economy related to the demand for regional activities. Soon shipbuilding began to become a matter of state, of imperial policy. This is something linked to the reinforcement of the Hispanic monarchy and the many attempts to centralize a hoarding of resources to face the announced war in Northern Europe and the defence of the extensive maritime empire. To what extent this affected local and regional economies is something that is still pending research, but the truth is that the Hispanic Monarchy began the search for the perfect ship. At this time, and despite García de Palacios'innovative proposal, the "*as-dos-tres*" rule would still be used, because of influences from the Mediterranean and more specifically from Ragusan builders. It must be said that from the end of the sixteenth century, the situation becomes complex when trying to separate what were really shipbuilding treatises from the many printed manuscripts, reports, and *memoriales* that were circulated, many of them in response to the debates about the fixed establishment of a royal naval architecture that was being enacted in the Council of State, in the Court, and in the circuits near the monarch. I will make a quick mention of them although it would be necessary to analyse in more detail the contents and, especially, the networks of influences behind these works that perhaps may not always be catalogued as shipbuilding treatises.

Works focusing on the construction of the second half of the sixteenth century are located in this treatise search for the ideal ship of the Atlantic: the first example is the work of Juan de Escalante de Mendoza (1575): "Itinerary of navigation of the seas and western lands" (*Itinerario de navegación de los mares y tierras*

[2] Edited in Lisbon, Academia de Marinha, 1991, Original Manuscript (1570).

occidentales). Escalante, born in Asturias, was general captain of the New Spain fleet in 1595 and died in Nombre de Dios (Panama) in 1596. The form of dialogue that appears in Escalante's *Itinerary* is used in various treatises as was customary in texts of the Renaissance and the Early Modern Age both in literary writings and in economic-political treatises or pamphlets. The first book of the *Itinerary* is dedicated to shipbuilding, describing the proportions and size of the ideal ship, as well as the materials required for its construction. As in later works, the ship is defined by a series of measurements, the main ones being the beam, the flat of the floor, the keel, length, and the depth. Very much in the Renaissance way, the proportions that these and many other dimensions of the vessel must maintain between themselves are established, so that it is enough to define the beam, measured in *codos*, to fix all the remaining measurements. Meanwhile, in 1587 Diego García de Palacio published "Nautical instruction for the proper use and regiment of the Naos, their design (*traça*) and government according to the height of Mexico" *(*"*Instrucción náutica para el buen uso y regimiento de las Naos, su traça y gobierno conforme à la altura de México*" (Fernández de Navarrete 1851, vol. 1, pp. 337–339; Picatoste y Rodriguez 1891, pp. 128–129; García Icazbalceta and Millares Carlo 1954, pp. 316–320).[3] Born in Ambrosero (Cantabria) in a family of navigators around 1530–1539, he experienced his scientific awakening in America, dying around 1595 (Manzano Baena 2003, pp. 17–19). His biography, his various positions in institutions, such as the Council of the Indies, the audience of Guatemala or The Royal Pontifical University of Mexico, where he was rector between 1581 and 1582, have been extensively studied. The same year of the publication of his work, in 1587, he was appointed by the Viceroy of Mexico, the Marquis of Villamanrique, Captain General at the head of a squadron with the aim of sailing from Acapulco in pursuit of Sir Francis Drake, but this fleet never went to sea.[4] Perhaps due to his experience as chief in charge of the war fleets, he wrote another work, the "Military Dialogues". His "Nautical Instruction" is divided into four books and only one is dedicated to the explanation of the construction of ships. It is written as a dialogue between a Biscayan and a mountain man. García de 's work is based on his experience on the Pacific coast, but we do not know where he got his knowledge on naval architecture. The interest of his description perhaps lies in the fact that he speaks of the "suitable ship", or ship adjusted to a trip, of 400 tons (*toneladas)*, corresponding to a beam of 16 codos. In reality, García de Palacios gave rules that deviated from the long-standing formula of "one-two-three" ("*regla de as-dos-tres", la "Santísima Trinidad*", that is, one cubit of depth every two cubits of beam and three cubits of length. His work is completed with a nautical vocabulary of more than 500 terms, including the first known preserved plans or drawings on naval architecture. Nevertheless, some scholars argue lines drawings did not appear until the eighteenth century but this is only a theory (Taylor 1958; Phillips 1987, pp. 293–296). There

[3] Archivo General de Indias (hereafter AGI,) Audiencia de México, vol. 1, fol. 40, (9th of May 1596).

[4] Letter to the King, Puerto de Realejo, Nicaragua, about Drake's incursion, 30 April 1579 http://www.mcnbiografias.com/app-bio/do/show?key=garcia-de-palacio-diego

are two copies of García de Palacio's treatise in the Library of the University of Salamanca and another in the Naval Museum of Madrid. Both copies are included in the compendium "Maritime Heritage". The "*Nautical Instruction*" shows similarities with contemporary Portuguese treatises, especially with the *O Livro da fabrica das naos* (Oliveira 1995).

The *Diálogo entre un Byzcaino y un montañés sobre la fábrica de navíos* may be included as part of the reports and manuscripts submitted to the Court or to the councils. However, if we compare it with the works of Cano, García de Palacios or Escalante, it is doubtful whether this "Dialogue", which appeared around 1630 should be considered as a treatise in the strict sense. According to Isabel Vicente Maroto, the manuscript of the "Dialogue" was the work of Pedro López de Soto, to criticize the ordinances of 1618 (López de Soto and Vicente Maroto 1998). The "Dialogue" disagrees with Escalante de Mendoza when he said that the Biscayan and Portuguese construction was superior to all its counterparts. The author of this dialogue "adduces as an example and justification of his proposals what was done in the Flanders Navy, the famous Dunkerque frigates, whose ships are built and manned following the Flemish systems, which the author recognizes as superior to the ones employed in Spain, superiority that he also attributes to the Dutch enemy" (Revuelta Pol 2017, p. 65) ("*aduce como ejemplo y justificación de sus propuestas lo hecho en la Armada de Flandes, las famosas fragatas de Dunkerque, cuyas naves se construyen y tripulan siguiendo los sistemas flamencos, que el autor reconoce como superiores a los empleados en España, superioridad que igualmente atribuye al enemigo holandés*"). He proposed "flat" ships, suppressing quarterdecks and castles, as well as improving artillery. The author proposes the construction of a 500-ton galleon according to his "*tratadillo*" so that the prototype can be verified.

At the beginning of the seventeenth century and in the framework of a political discourse that overstated the importance of shipbuilding, the work of Tomé Cano, deputy of the University of *Mareantes* of Seville and pilot of the *Carrera de Indias,* born in Tenerife, was published in Seville (Cano 1964). The importance of the context in which this work was written is related to the political influence of shipbuilders and members of the navies related to the business of the *Carrera de Indias*. This is more important than one might think at first sight since evidence of a rivalry in regard to the systematization of the architectural rules for ships that had to navigate in the Atlantic fleets and galleons is glimpsed between regions, especially between Andalusians and Basques. The builders Juan and Lucas Guillén de Veas "master shipbuilder for his majesty" (sic) supported Tomé Cano's system and thereby established new rules for the so-called new ship factory (*Nueva Fábrica de Navíos*). Apparently, Tomé Cano's work was written around 1607, although it did not begin to be published until 1611, coinciding with the promulgation of the first ordinances. It is written in the form of a conversation between three people while they sail down the Guadalquivir: Gaspar, Leonardo, and Tomé, someone who acknowledges having travelled 53 years to the Indies completing 29 trips, perhaps a hagiography of the author himself. Cano's work is a treatise on naval architecture that also criticizes the naval policy followed by the crown. For him, this business is not profitable for the shipowners and he proposes that the king maintains his own ships, as a royal navy. From his experience in the fleets that travelled between Seville and Veracruz, he knew what the indiscriminate use of old and damaged boats could entail. In fact, in 1617, he had to answer to the Casa de la Contratación for running aground and abandoning ("*echado al revés*" sic) the *nao Santa María de la Rosa*, because it was useless for the return trip to Spain (Cano 1964, pt. Introduction of Marcos Dorta, p.19). The problem with his work is that it does not include plans or drawings as in García de Palacios' work. But like other treatises, it establishes the measurements of all the parts and elements of the ship starting from and in proportion to a main measurement, the beam. It proposes a beam of 16-*codos* and a keel of 34 *codos*. Actually, the measurements proposed by Tomé Cano are similar to the ones of the Ordinances of 1618, which were promulgated to abolish those of 1607. Is this perhaps a triumph of the social groups of shipbuilders and members of the fleets of the *Carrera de Indias*, such as the Veas brothers? Cano elaborates extensively on the measurements of the *naos* starting from that of the beam, which is the "*Foundation of the entire construction*", from which not only the hull but also those of the masts, top-masts, yards, etc. are derived. Cano takes the 16 *codos* beam *nao* as a model, to which he gives six *codos* of depth on the first deck and 34 *codos* of keel length, proportions that are maintained if the beam increases. Cano asserted that the newly manufactured ships are supposed to have larger keels.

Despite the enormous shipbuilding activity between 1589 and the second half of the seventeenth century, in parallel with the promulgations of multiple ordinances, legislative compendia, and contracts, it can be said that the industry does not experience a new boom until the second half of the seventeenth century. Around 1635, it seems that a new book on construction was written by the admiral of the Indies fleet, Jacinto Antonio de Echeverri. According to evidence it was an "incomplete and anonymous speech on shipbuilding" ("*Discurso incompleto y anónimo sobre construcción naval*"). It is likely that another work signed by Juan de Echeverri[5] was written in 1673. Other treatises have remained less visible, such as works written by Diego Brochero, Juan de Veas and Diego Ramirez (1614), López de Guitián (1630), and Juan de Echeverri (1673) (Fernández Duro 1880; Hormaechea et al. 2012, vol. 2). In the last decades of the seventeenth century, most of the information related to shipbuilding is compiled in the "Compilation of the Laws of the Kingdoms of the Indies" ("*Recopilación de las Leyes de los Reinos de Indias*"), approved in a pragmatic of May 1680 and edited on repeated occasions. Apart from this legislation, the figures of two writers appeared in the last decades of the seventeenth century: Antonio de Gaztañeta e Iturribalzaga and Francisco Antonio Garrote. The first, Antonio de Gaztañeta (1656–1728) is perhaps one of the most important geniuses of construction and he developed his extensive work between 1688 and 1723. In 1688 he would publish the "Art of building royals" ("*Arte de fabricar reales*") in manuscript form, as a chronicle of the process of construction of two galleons, the Captain and the Admiral of the Navy of the Ocean Sea (*Armada del Mar Océano*) published in facsimile in 1992 (Gaztañeta e Iturribalzaga 1992). He would also be

[5] MNM. Colección Vargas Ponce, VII, Doc. 62, fol. 74; T. XVIII, Doc. 112, fol. 155.

the author of: “North of navigation found by the reduction quadrant” (“*Norte de la navegación hallado por el cuadrante de reducción*”) (Gaztañeta e Iturribalzaga 1692); “Universal geometric quadrant for spherical conversion to planes, applied to the art of sailing (1693)” (“*Cuadrante geométrico universal para la conversión esférica a los planos, aplicado al arte de navegar*”); “Proportions of the measures arranged for the construction of a war vessel of seventy *codos* of a keel” (1712) (“*Proporciones de las medidas arregladas a la construcción de un bajel de guerra de setenta codos de quilla*”), and the “Proportions of the most essential measures for the manufacturing of new ships and war frigates”(Gaztañeta e Iturribalzaga 1720) (“*Proporciones de las medidas más esenciales para la fábrica de nuevos navíos y fragatas de guerra*”). His work is key to understanding the construction of the last galleons, although it is a set of documents where the author collects notes. There are 293 pages numbered from 001 to 286, plus 199 repeated, and another seven preliminary pages without a number. Only 196 pages have something written, and the remaining 97 are blank pages apparently reserved to continue writing. His work collects notes regarding the construction of different ships, such as the Captain and Royal Admiral of the Navy of the Ocean Sea, and the San Francisco galleon that was built for the *Carrera de la Plata*, but the central subject is the description of the construction of the Royal Captain of the Ocean Sea, *Nuestra Señora de la Concepción y las Ánimas* (Fernández Duro 1996; Apestegui 1998). The work of Francisco Antonio Garrote, “Measures given for the construction of a 60-gun frigate, and response of the Marquis de los Velez to Captain Garrote”(“*Medidas dadas para la construcción de una fragata de 60 cañones, y respuesta al Capitán Garrote del Marqués de los Velez*”) appeared in 1690, offer construction models opposed to those of Gaztañeta. The analysis of these works, due to their size and characteristics, deserves a separate study.

2.1 Legislative Compendia, Sets of Ordinances, and Cédulas

The Hispanic Monarchy began to legislate on shipbuilding in the sixteenth century. Between 1503 and the legislation of the fleet system in 1561 projects containing some provisions on the type and tonnage of ships were developed for the organization of fleets and navies. Related precisely to concern for the ships of the *Carrera de Indias* and the composition of the fleets from 1521, measures were initiated for the protection of fleets and navies, fixing convoyed navigation with armed vessels for the entire trip protected by a navy ship. The “Armada de Guarda Costas” (Coast Guard Navy) was also created to protect the Canary Islands-Azores-Sanlúcar de Barrameda triangle, a problematic and dangerous area due to the presence of enemy fleets as well as other specialized navies in areas of geographical influence as political-military and commercial influence of the Hispanic Monarchy during the Habsburg era was expanding. These facts were essential to review and legislate on the tonnage of ships. The increase in the tonnage of the ships was a direct consequence of the protection and improvement laws of the navies and fleets of the Indies.

It might seem that the Crown was more interested in the ships than in the protection of the ports. The ordinances of the sixteenth century on the tonnage and supplies of ships also set the equivalences of measuring units. For example, the volume of the Castilian barrel (*tonel macho castellano*) was equivalent to that of the ton: 1385m^3. In 1522 the minimum size of the Carrera vessels was 100 tons, but there were variations in 1531, 1534, 1535, 1539, 1541, 1543, 1550, 1552, 1568, and in 1587 the minimum size was already 300 tons although there were cases of up to 500 tons.

The documentation of the period mentions the lack of prudence of the masters of *naos* when overloading the ships, the reason that led to the creation of the Visitor of Sanlúcar de Barrameda as well as of Seville, and other figures to monitor that the laws of the Crown were fulfilled (Mira Caballos 2005, pp. 32–33). But the law and the practice were discordant. Discussions on ships with shallow draft and light weight to "discover" took place, a dilemma that became the eternal subject of debate by the Spanish Crown. It was contradictory to search for the perfect ship with shallow draft (to access rocky coasts, explore, return to Seville going up the sometimes shallow Guadalquivir, or access the ports of Flanders during war) but sufficient strength and cargo capacity to load goods and artillery. For three centuries, shipwrecks were caused by running aground on the rocks, especially in the Gulf of Mexico, the Caribbean Sea, and in the Antilles. And this was even more serious since whenever there was war in Europe, ships from the Carrera fleets were seized to go to the war navies. In fact, in his report of 1556, Pedro Menéndez de Avilés complained that all the ships going to the Indies were old, after decades of attempts by the Spanish Crown to organize the fleets according to models that were already unpractical for the ocean route. This report of 1556 was the one that would soon become the basis of the Indies fleet system from the decree of July 16, 1561. Apart from the considerations devoted to how navigation should be organized, this *memorial* highlights the need to build "the best ships that sail by sea", insisting on a latent problem since 1534. However, Menéndez de Avilés did not see as prudent the construction of ships weighing more than 400 tons due to the problem that it would entail when trying to navigate the Guadalquivir river upon return from America and demanded to watch over masters and shipowners who used to make alterations in the hulls in order to increase cargo capacity on the ships.[6] But Menéndez de Avilés was not a shipbuilder, he was a governor and sailor. The discussions between Cádiz and Seville for the possession of the port for the Indias trade would drag on for centuries until in 1717 the *Casa de la Contratación* (Spanish Board of Trade) was transferred to the Bay of Cádiz. In this context, galleon construction experiments were carried out in which their tonnage tended to increase, making it increasingly difficult to navigate the Guadalquivir to Seville, as was the case with the ships built by the Genoese merchants Grillo and Lomelin, the galleons "*de plata*" built around 1660 (Serrano Mangas 1989).

[6] Archivo General de Simancas (hereafter AGS). Consejo de Castilla, 46, document number 38. Report of 1556: "Memorial sobre la navegación de las Indias, hecho por Pedro Menéndez de Avilés que fue por capitán general a la Nueva España y vino de ella, año de 1556".

The sixteenth century remains a mystery due to the apparent scarcity of official treatises and the evidence of the circulation of naval knowledge that would soon afterward lead to a legislative body on what we could call an official naval architecture of the Hispanic Monarchy or, the debate on its legal and strict systematization.

It must be said that the great legislative period on shipbuilding did not appear until the first decades of the seventeenth century, a stage in which the shipbuilding industry was intended to be more controlled by the political authorities, leading to the enactment of ordinances. The seventeenth century continues the trend of perfecting the oceanic ship with fixed proportions according to a mathematical model. The proportions are fixed in the ordinances of 1607, 1613, and 1618 (Rodríguez Mendoza 2008). It must be emphasized that the process of promulgation of the ordinances involved a parallel experimentation, as well as discussions between experts and elites close to political power. The ship became a matter of state and on many occasions a good part of the regulations intrinsic to its construction remained within the scope of political "secrecy". One of the figures behind the first shipbuilding ordinance was Admiral Diego Brochero, who addressed a speech to the king, with a report inspired by Tomé Cano's work, after previous consultations with the Duke of Medina Sidonia. In 1594 he was appointed Admiral General of the Royal Navy of the Ocean Sea.[7] By royal order he was called to the council of war as a result of the issuance of his *memorial* to the king, in which he made known a study and consideration of the state of the navy, emphasizing and denouncing the bad treatment, lack of consideration, and contempt for the sailor, the defective armament of the ships, "*there being no one who knew how to handle them, nor a school where to learn it*" (*no habiendo quien los supiera manejar, ni escuela donde aprenderlo)*. Brochero drafted and put into effect some "Ordinances for the navies of the Ocean Sea and fleets of the Indies" (*Ordenanzas para las armadas del mar Océano y flotas de Indias*), signed in 1606, shortly before the Cédula of the Ordinances, issued in January 1607. This document, analysed by Goodman, exposes the need for reforms in the organization of the navy, but stops at the ships that were to be built for the constitution of the navies and fleets (Goodman 1997, p. 242). In 1605 Brochero proposed a new design for longer, narrower vessels that were lighter and more manoeuvrable. He commissioned the construction of 15 warships of less than 200 tons, but this first attempt failed, although an important advance was made: two iron *brazales* (bracers) were installed on the hull to set the allowed float limit in order to prevent shipowners, in their greed, from overloading ships. This measure was a consequence of the shipwreck of poorly designed ships in the West Indies. It should be added, as a curiosity, that the Spanish created the waterline 270 years before a certain Plimsoll, which is why it is called in English the Plimsoll Line or the Water Line.

[7] AGS. GA 604, Consulta del Consejo de Guerra, 7 oct. 1603, Consulta de la Junta de Fábricas, 23 julio 1603.

The first Ordinance was created in 1607 and it established measures for each tonnage and type of galleon to be built. Apart from the measurements, *codos*, tons, and proportions, issues related to the concerns of the Crown were specified, especially the cargo that each ship had to carry according to its tonnage: "*The Indias contracting house that resides in Seville must name a person of science, and conscience who recognize, look, and consider what each ship of these measurements can carry, so that it can leave, and enter through said "*barras" *(estuaries and sand banks) without lightening the cargo on board, and safely make its navigation; and because the owners of* naos*; and loaders cannot use their disorganized greed to use deception, close to this person said two iron signals in the stem, and stern of each ship that serve as a limit so that until there, and no more the ship is loaded, so that the iron, or signal is above water, and this person has a book in which the part where it touches on the Ship the said signals declaring in how many* codos *of water is that sign*".[8] Although the Ship Certificate of Tonnage of 1613 is the most complete, previous measures had already been established for the gauging of the *naos* of "privates taken for the service of my navies". ("*navíos de particulares que se tomaren para servicio de mis armadas*"). The regulation of labour in this ordinance is significant. It even described the tools used by the "armadores" "*And because it is the custom among the armorers not to bring the necessary tools required in their labour, respect for which I ordered to provide them with tools, which they lose, and take from each other, and for lack of them they use the ax, which is the ordinary one they bring, and with it they waste a lot of wood, and spend more time in what they crave, considering this, it is considered convenient for my service, benefit of the Royal estate, utility, and profit from the same armorers, which, like the ordinary salary that has been given to them up to here, has been four reales, be four and a half each day in the lordship of Vizcaya, Guipuzcoa Province, four villas on the coast of the Sea, Asturias, and Reyno de Galicia with the condition that none of our Carpenter, nor the caulkers can carry more than two apprentices, and the cable makers one, and these should not be paid more than they deserve according to the sufficiency of each one that has to appear in the factories to the superintendent of them, and in the navies to the captain of the armorers, with the condition that from now on I myself will not give them any kind of tool, other than the grinding stones, and to the officers who are from houses will not be given this salary entirely but to each one according to what they deserve* " (*passim*).

In 1607, the king "being my Navy of the Ocean Sea in the river and port of the city of Lisbon (sic)" (Fernández-González 2010) described the tools and the work in the port: *The carpenter must bring ax, saw, or saw,* ariela (plane?) *of two hands,* gurbia (curved chisel?)*, three types of drill bits, a hammer, a mallet, and two chisels. The caulker must bring caulking mallet, five caulking irons,* gurbia *(curved chisel?),* magujo*, mallet, hammer, ripping hook, three different drill bits from the aviator thickening. The Cavillador* (treenail maker?) *must bring drill bits,* aviadores*, drills, and mallets.* In other documents we learn that caulkers use caulking irons, devil

[8] Quoted in Fernández de Navarrete, MNM, fols. 588–590.

irons, caulking mallets, shot plugs, breaming hooks, scrapers, and ripping hooks. The theft or loss of the tools of the armourers was severely punished with the penalty of 5 years rowing in the galleys. The promulgation of the Ordinance of 1607 was displaced only a year later by the contract signed by Vicencio Centurión and Ambrosio Spínola in 1608. In 1613 a new Ordinance for the ship factory is stipulated, on important dates, after the signing of the Peace of London in 1604 (Fernández-González 2010). These Ordinances of 1618 affected both warships made for the king and merchant ships promoted by individuals. They were intended to be compulsory, establishing 14 orders of ships depending on the size of their beam, from 9 *codos* of beam to 22. It calls all ships under the type of ships and does not distinguish between war and merchant ships. According to Revuelta Pol, "Comparing the main measures contained in the works mentioned above, including the Ordinances, an evolutionary process is observed in the ships, with a tendency to greater slenderness, both due to the increase in the keel-to-beam ratio and to the decrease of the volume of the quarterdeck and castle, making ships more "flat" (*razos)*, an expression used by Christopher de Barros as early as 1581, equivalent to the English term "razed" or "race-built", applied to the improvements introduced by Hawkins in the English galleons by that same time. Coincidence little known to British historians" (Revuelta Pol 2017, p. 63).

The ordinances seem to have remained in force except for modifications introduced in 1666 and 1679. In the second half of the seventeenth century the ship of the line was consolidated in England and in Holland, making the galleon obsolete. It was a ship capable of integrating the function of war and armed transport, with artillery and not only subordinated to boarding techniques, such as the galleon. The "Compilation of the Laws of the Kingdoms of the Indies" published in 1681 includes almost all, practically, the previous legislation, since the time of the Emperor Carlos V (Fernández-González 2010). It cannot be forgotten that all this legislation was made in parallel to several attempts made in vain by the Crown, to unify and centralize the navies between 1604 and 1643. In 1624 the Admiralty Board sent watchmen to the kingdom's ports so that the product of their collections (fines for trade and for contraband generally) would be used to manufacture and assemble galleons. In 1647 Don Juan José de Austria was named Captain General of the Sea (Ceballos-Escalera y Gila 2012).

2.2 Representations and Reports to Boards and Councils, in Some Cases Drafts of Treatises That Were Never Published or Less Well Known

How was the knowledge process to improve naval architecture developed from the first phases of the maritime worldwide expansion? The problems arising from the debate between the administration and the contractors implied that the fleets were either owned by the crown or had to be built privately and were directly related to whether the ship was really capable of fulfilling the dual merchant and warfare function expected of it. Historically, the most closely linked areas to naval manufacturing were the Cantabrian Sea, the Andalusian Atlantic coasts, and the Mediterranean façade. These areas were not completely isolated from each other. In fact, there was a lot of rivalry between them and sometimes cooperation, but above all, from all these areas, *memoriales* and reports were sent to the Court and the royal councils with the intention of promoting a certain type of trade and constitution of navies, and especially, a model ship. This was a reflection of the fragmentary constitution of a Monarchy that encompassed different kingdoms and states with different cultural and technological traditions.

A classic idea repeated in Spanish historiography is that technological progress during the fifteenth and sixteenth centuries arose from the integration of two construction traditions from the Mediterranean geographical areas and adaptation to Atlantic navigation requirements. This hypothesis aims at simplifying the apogee of a long tradition of technological transference resulting from the practical experience of sailors and builders, such as the Niño family or the Pinzón family. These were Mediterranean merchants—trading between Italy and Southern Spain—at the end of the fifteenth century, and their experience facilitated the development of navigational skill for the Atlantic Ocean exploration. It is true that from the thirteenth century the typologies proliferated and multiplied, although they shared some basic characteristics in the structure: "*the frame-based structure, carvel planking, rigging with bowsprit, fore, main, and mizzen masts, on which square sails and lateen sails are mounted*" (Revuelta Pol 2017, p. 56). Based on this scheme, galleys, *galiotas,* and *galeazas* were built in the Mediterranean, where Venetian and Ragusan experience was important. It cannot be forgotten that a good part of the ships that served the Spanish crown were built in the Italian ports, especially in Naples and Sicily. Before the fifteenth century, the naval industry of the north of the Iberian Peninsula fueled the campaigns of the *Reconquista* war in Andalusia while later, in the sixteenth century, it was the source of a large proportion of the ships built for trade with America that left from the shores of the Gulf of Cádiz, as Seville was the official capital of this trade by royal decree. An important shipping activity in Barcelona also developed following construction of the great arsenal of 1378. Shipyards built in the Middle Ages, such as at Seville, Malaga, Valencia, and Barcelona, generally continued to be used during the reign of the house of Austria, although in the sixteenth and seventeenth centuries shipbuilding was promoted in Orio, Pasajes, Bilbao, Deusto, Zorroza, Portugalete, Castro-Urdiales, Santoña (Colindres), and Santander (Guarnizo) in the north. In Andalusia there were small shipyards in San Fernando, Sanlúcar, and Algeciras, while on the Mediterranean coast, apart from the shipyards in Barcelona, Valencia, and Malaga, there were shipyards and arsenals in Cartagena, Alicante, Denia, Tarragona, Tortosa, Badalona, Arenys, San Felíu de Guixols, Mataró, Masnoy, Palamos, Ibiza, and Mahón. As yet, the importance of each of these shipyards on the Hispanic naval map is relatively poorly understood. Regional studies are important to understand the transfer of technological knowledge that occurred in and between shipyards (Olesa Muñido 1968, vol. II, pp. 894–902).

In the last decades of the sixteenth century, significant events took place for the subsequent development of the naval industry and architectural models. In particular, the Cantabrian-Basque areas, Galicia, Catalonia, and western Andalusia began different phases in terms of construction models. Until now very little is known about the possible influences, reciprocal interactions or innovations that occurred in each area from a comparative perspective because most of the current literature on the subject is based on the study of local and regional characteristics of this industry. Another main event, without a doubt, was the crisis produced by the loss of the Navy in the 1580s, in the battle against England in the North. At the same time, Guipúzcoa (especially Pasajes and Oria) became important centres of specialized naval production in the construction of large ships for the Royal Navy and Fleet and for the *Carrera de Indias* (Odriozola Oyarbide 1998, p. 93). In these decades, coinciding with the institutionalization of the Carrera fleets, the origin of most of the ships destined for these fleets was Cantabrian. However, almost at the same time as the American expansion, a shipbuilding industry began in the Indies, with the launching of the first ship built by the Spanish in America in 1496, and reaching a certain scale at the initiative of Cortés from 1519 onwards (Gardiner 1954). Other American centres became cores of local shipping industries, such as Guayaquil. Cuba, specifically Havana, also experienced an early construction period before becoming the important arsenal that developed in the eighteenth century (Clayton 1978, 1980).

The regulation of the *Carrera de Indias* war and merchant navies produced endless information regarding the construction, characteristics, and tonnage of the ships. However, the most accurate sources about what was really happening in local shipyards and arsenals are the reports and *memoriales* on specific cases of ships, galleon, and fleet construction, of which there is much documentation. Much of it is contained in the Vargas Ponce Collection Catalogue and many of these cases have been studied by Serrano Mangas, Mira Ceballos, or Casado Soto. Reading all this enormous documentation that goes from certifications or Royal Certificates for the purchase of materials for the galleon shipyards and construction of various types of ships, to more precise documents on shipbuilding, it is possible to extract detailed information worthy of being codified in a database. Part of this documentation comprises or makes reference to *memoriales* of shipbuilders and it is still largely unknown. As a general rule, these *memoriales* had constructive measures for the concrete formation of specific and determined squads and navies, such as the case of the Antonio de Oquendo fleet in 1623, or when the *Avería* (tax to cargo) system contract was imposed. Depending on each situation, new features were introduced in the construction, such as when “the keel was lengthened and the draft was decreased”, that is, they became more galley like, in the case of the galleons of the Navy of the Ocean Sea (*Armada de la Mar Oceána*) (Serrano Mangas 1989, p. 21). The prototypes for the construction of “galley-like” galleys or galleons are not in the ordinances, not in the treatises or in other official documentation, but it is visible in this type of document. It would be necessary to make an ordered list of all this documentation with the express contents in relation to the innovations little by little agreed upon experience for the introduction of architectural innovation. It was in this dialectical context between the needs of the *Carrera de Indias*, that is, the defence and maintenance of the commercial system with America, and the offensive policy in northern Europe, that the galleon emerged as the quintessential model of Iberian construction. The galleon is a product of an evolution, a product also, of the state and private interests, whose construction system was partly veiled by the "war secret" and which gathers in its architectural methodology traditions from different regions connected to the Hispanic Monarchy, a subject that has yet to be studied in depth. In times of war, the best equipped galleons were assigned to different service commissions. The first regulations were not in the form of ordinances, but in the form of "*reales pragmáticas*", granting of bonuses, and "*acostamientos*" by which prizes were awarded to those who manufactured large ships, as well as *cédulas*. Ship manufacturers were expected to build vessels of 1500 or more *toneles*.

At the end of the seventeenth century, there is a large number of *memoriales* on shipbuilding, such as the *memorial* of Diego López de Guitián Sotomayor, quoted by Serrano Mangas, which argued that galleons needed to be strong with good sailing characteristics and therefore should be built with a long keel to avoid major damage in Atlantic storms such as dismasting (Serrano Mangas 1989, p. 21).[9] Serrano Mangas analyses how, at that time, the construction of an Armada galleon (Armada's ship or escort, destined to fight) was differentiated from the "*Galeón de Plata*" (Silver Galleon), which accompanied the Indies fleet and protected the precious metals it carried. Very early in the seventeenth century, a problem that conditioned the shipbuilding of the Carrera ships was the Sanlúcar de Barrameda bar, which complicated navigation at the entrance into the river Guadalquivir. In 1623, Antonio de Oquendo admitted that the 600-ton ship *Santiago* "to be able to enter and exit the bar and on the first voyage he acknowledged that it was not appropriate to navigate the Carrera".[10] Another problem was the controversy between awarding contracts and the centralization of construction in the hands of the Crown. Curiously, despite the ordinances imposed between 1607 and 1618, the contract system continued to be used. Juan de Amassa and other shipbuilders proposed different prototypes for the construction of more appropriate vessels for the *Carrera*. The contract system was backed by the shipbuilders and *armadores*. For example, in his *memoria*, Juan de Amassa (1635) recognized: "*And recognizing his Majesty as impossible to preserve this Monarchy without the help of the ships of private contractors, only with his Majesty's own war ships, it has been the only remedy to find a way to build ships that carrying the cargo carried by the merchant, have the ability and convenient disposition to carry two lines of artillery to have within itself not only enough defence, but also to serve at war with the advantage of two artillery weapons as long as it is in his Majesty's service*".[11] Other initiatives like those of Tomás de Larraspuru or Francisco Díaz Pimienta contributed to continue the debate on shipbuilding. Larraspuru (1582–1632), a Gipuzkoan sailor and general in the service of

[9] MNM Mss. 1311, Memorial.

[10] MNM, Mss. 84. Report of the Contratación about the barra de Sanlúcar.

[11] AGI, Indiferente General 1872, Memorial of Don Juan de Amassa, February 1635.

the King, conceived a model of a boat as a product of his extensive experience suffering the problems of the Guadalquivir bar and the Seville monopoly. In 1625 and 1629 he had to observe the sinking of his admiral ships from the fleets he commanded at the Sanlúcar bar when he returned to Seville, as well as a *patache* and the stranding of three silver galleons and two merchants. In 1631 Larraspuru launched in the Havana shipyards, after applying some technical recommendations from Macebrandi and Bartolossi, a galleon, with clear influences from the Ragusan school. However, a report prepared by the Casa de Contratación in 1675 on the Sanlúcar bar, said that: "*General Tomás de Larraspuru built, with the same intention of entering through the bar, the galleon Marimorena, and it was recognized not to be on purpose because it threw the men from the decks by balancing, and of three trips it made, in two it returned dismasted, throwing in the last trip all the three masts and all these losses have not been due to stormy accidents, to which vessels are subject everywhere, but originated in the Sanlúcar bar*" (Fernández de Navarrete 1995, pp. 725–726; Fernández Duro 1996, pp. 295–297).[12] For his part, Antonio de Lajust, built ships for the Carrera until 1629.[13] He commanded the *San Antonio*, which was part of the 1630 New Spain fleet under the command of General Miguel Echazarreta. He was replaced by Admiral Manuel Serrano captain of the galleon Nuestra Señora del Juncal, which sank in the Gulf of Mexico.[14] Lajust's *nao* also wrecked "a league to windward from the port of Tabasco" with a load of cochineal (cochinilla) (Peñaflores Ramírez 2008).

These shipbuilders were also technicians who improved the construction and sometimes also contractors because they acquired obligations with the crown to build ships according to some characteristics that they expose in their *memoriales*, in search of the perfect ship. Some of them wrote *memoriales* that we can consider small shipbuilding treatises, but we only know others from indirect documentation about their construction projects, especially consultations with the Council of the Indies or the Indies and Navy War Board. Sometimes, they erred in their architectural calculations, they experimented like Alonso Ferrera or Juan de Hoyos, who were contract-builders. The provisioning of naval supplies (*avituallamiento*), a term under which everything a ship needed for its rigging and finishing was included, was also subject to the competence of the Council of the Indies and the Junta, which in addition supervised the transport or importation of timber. The parallel organization of various boards, such as the Board of Works and Forests Del Soto de Roma (in charge of timber supplies to Cartagena, Badajoz, Cádiz, Seville and Malaga) as well as many other meetings held in 1603, 1621, 1624, 1627, 1640, and 1656 and

[12] MNM. J. A. González Pañero et al., Catálogo de la colección de documentos de Sáenz de Barutell que posee el Museo Naval (serie Simancas), Madrid, 1999, Mss. 372, n° 105, 106 y 107; MNM. Catálogo de la colección de documentos de Vargas Ponce, 1999, serie segunda: numeración arábiga, vol. III, ts. 3, 13 y 14A, págs. 21, 141, 150, 154, 163 y 167, docs. 198, 206, 209, 211, 19, 119, 5 y 35;

[13] MNM Mss. 40. Memorial de las naos que ha fabricado Antonio de Lajust desde el año de 1614 hasta el de 1621.

[14] AGI, Contratación 1178, N. 1.R.1.

the fact that the experimentation of naval construction coincides with activities to convert forest areas into places for timber supply makes the documentation related to this issue dispersed and makes the research work difficult.

This section would include shipbuilding projects, which proliferated from 1540 onwards. Álvaro de Bazán's project, for example, discussed at these meetings in 1540, was aimed at creating a naval system which was different from the existing one. Bazán presented several projects and he signed a contract based on the construction of three galleons and six *galeazas*. It received widespread criticism, including from the Council of the Indies and Menéndez y Valdés himself (Mira Caballos 2005, p. 52 et seq.). In part, his projects failed because in return he asked for too much, a kind of exclusive contract over the Indias trade or a monopoly on the sale of colonial merchandise to which the merchants were opposed. However, this project is the precursor or inventor of the *galeaza*. "They will be galley and galleon bastards, and they will not have as much of a galley as the Venetian ones because they are very shallow on the side to go to the Indies, they will have 200 *tonelas* more or less. These ships will be very light from the sails because of a certain secret that they will have in the making and in the sails, so much that no ship of those that have gone to India (...) sails as much as they do" (Mira Caballos, passim). It had oars, destined only for the operations of exit and entry to the port or at the time of positioning the ship for battle, hunting or fleeing from another vessel. The fourth project was accepted by the emperor on October 7, 1549. In this project, Bazán promised to prepare six galleons (three ordinary and three of new invention) (Galeones de "Nueva invención" of the Marquis de la Bazán) and three *galeazas* 4 months after the signing of the contract. This project introduced technical improvements for the galleons: "The cut or gauge of the plan and of what goes underwater of the said two galleons is and goes in such a way and measures and so different from those used that for this reason and because of their size and shape they are very light".[15] The contract was signed in Valladolid on February 14, 1550 (Mira Caballos 2005, p. 56). In this context, the supervision of the fleets of the *Carrera de Indias* became a central issue in the debates in boards and councils. The *Carrera de Indias* will reinforce a rivalry between the Andalusian and the Guipuzcoan schools of builders in relation to shipbuilding.[16] This rivalry carried out by the Seville seafarers' guild against the Guipuzcoan builders had ups and downs due to the convenience of organizing the fleets in convoys and the monopolistic intention of locating the final departures and arrivals in Seville where traffic should be controlled despite the concessions made with many peninsular ports. Bernardino de Mendoza's project appeared around 1548, and although he was not the one who invented the convoy system, his project was the one that succeeded in 1561 with the Ordinance of the Fleets and Galleons

[15] AGS, Consejo y Juntas de Hacienda, 20–45, passim.

[16] MNM. Colección Vargas Ponce. Three "representaciones", to the King, to the Consejo de Indias and to Juan de Idíaquez y Diego de Ibarra "sobre la pretensión de los mercaderes mareantes de Sevilla de ser preferidos a los fabricantes de naves de Guipúzcoa para la navegación de la Carrera de Indias", Doc. 58, 1612, fols. 88–89.

System.[17] The report was also addressed to Juan de Idiáquez, who had had, as a war adviser, an active role in the preparation of the Invincible Armada of 1588 and was very strongly linked to the Duke of Medina Sidonia. Further, systematic analysis is needed on the large body of unpublished documents related to this debate, associated grievances, and the prevalence of the fleet system and particular types of ships. Years of debate and competition went on around the construction of ships with the rivalry between Seville and Guipúzcoa, and the "*visitas de navíos*" (inspections) of the ships of the *Carrera de Indias*, some built in Guipúzcoa, in parallel with the continued demand for ships for war and trade. The Atlantic trade required the construction of high tonnage ships and equipment to make the *Carrera* as safe as possible. It was the search for the perfect merchant and war ship that creates the form of the galleon. These ships had to make port in New Spain, Nombre de Dios, and Santo Domingo as well as many other particular Antillean areas with hazardous coastal features such as rocky bottoms and coral reefs that produced continuous shipwreck events. In addition, Bernardino de Mendoza's project was criticized as the *galeazas* that carried oars could be a problem due to the excess of human presence on board. Mendoza proposed a system based on fleet navigation and that each ship that joined the fleet was well equipped and in good condition although he criticized the *avería* (taxation) system.

2.3 Correspondence, Entries, Contracts, and Other Documents

From the beginning of the sixteenth century, there is information in private correspondence and manuscripts specifying the need for ships and their mobilization at sea which, little by little, influenced the delivery of detailed reports and literature on shipbuilding that encouraged change or adaptation of precedent constructive models. This experimentation, as we have said, in the hands of *carpinteros de ribera*, was reflected in the construction of various typologies. Galleys were typically rigged with a main mast and at most another mast in the bow, the foremast, which held lateen or triangular sails. Such an arrangement had been shown to be more suitable for Mediterranean winds when used as an aid to the strength of the oars. Although the galley's purpose was primarily for war and did not have much draft, many galleys were used to carry merchandise—this combination of commercial and military use was frequent from the thirteenth century onwards. Until the end of the seventeenth century, galleys formed the backbone of the war fleets that operated in the Mediterranean, and they did not disappear from its waters until well into the eighteenth century. However, the substitution of propulsion by oar by that of sail became widespread from the beginning of the seventeenth century. In a letter sent from the Duke of Osuna, in Naples, to Felipe III on June 2 1618, he comments on the interest of Berber pirates in round ships (*naves redondas*): "having seen how

[17] AHN, Diversos, Doc. de Indias, núm. 93, fol. 1r-5v

little they knew of round vessels, not long ago, today they disarm their galleys in order to arm round ships" (Fernández Duro 1885, p. 362; Fernández Izquierdo 1989). At the beginning of the reign of Felipe II, the poor condition of the galleys led to a reform to replace contracts by direct administration at the hands of the king's officials, in 1557, thus increasing both their number and the state ownership of these fleets of galleys. New contracts were signed with the Duke of Medina Sidonia and with the Marquis of Santa Cruz (Phillips 1991, pp. 207–209). As in the case of the galleys, other types of ships were built by the contract system between private merchants and the Crown. A good part of these contracts was produced as a result of the debates that took place in the special meetings organized in the Court. In 1584 there was a Galley Board (*Junta de Galeras*) in Madrid to resolve the dilemma between contracts and administration, which was resolved in favour of the contractors.

From a comparative point of view, the descriptions of ships contained in the documents generated by these Boards and meetings between experts and between these and members of the Council refer to descriptions where the search for an ideal size of ship is seen, sufficiently important as to be armed and light and aerodynamic, or hydrodynamic to be able to overcome, when returning from trips to America, the bar of Sanlúcar de Barrameda. However, the safety of navigation in these areas affected the entry into channels and ports in various areas, whether they were the *Carrera de Indias* ships or the Dunkerque fleets. This technical circumstance could be said to have greatly affected the measurements of galleons. The Spanish crown insisted on the construction of large ships, as this was supposed to give them ease of naval combat. The load capacity of each ship was measured in tons (*tonelas*), that is how many barrels of a certain size each ship could carry. This and other manuscripts discuss the advantages and disadvantages of smaller or larger ships. Escalante de Mendoza maintained that the ideal ship for the Indies route should be 500 tons, on average: Galleons could have about 1000 tons and smaller *naos* or *naves* 100. The discussion on the measures and their usefulness given the geographical and technical constraints is present in almost all the documentation of contracts. Builders, wood merchants, and members of the Councils had a difficult challenge to meet: they needed large ships with artillery but at the same time with great draft to load merchandise while they could be easily manoeuvred when crossing the channel of the Guadalquivir, the rocky shores and reefs of the Gulf of Mexico, or the harsh conditions of the North Sea and access to the Flemish river ports. Having it all at once was almost impossible although it should be noted that the galleon was the centre of the great debate of the Crown of Castile. These vessels were built by contract with an *armador de navíos* or *asentista*: a style that apparently prevailed. But the king's officers participated, mainly in the provision of materials, especially wood, which was a global trade that came to be controlled and intervened through numerous networks in which the elites near the crown, the contractors, and merchants, many of them foreigners, participated. Much of the documentation on seats and contracts is catalogued in collections such as those in the Madrid Naval Museum (the Navarrete and Vargas Ponce collections). However, there is still a lot of unpublished documentation and some other that has been the subject of monographs.

Among the latter are the works on the 12 galley-like galleons built by Menéndez Avilés in 1568 in Deusto and the "other" 12 galleons built in Guarnizo between 1589 and 1591. Sometimes the use of the same name or concept for different projects can be confusing. Other cases are, for example, the "asiento" of Gregorio Sarmiento's *galeaza*, from 1589[18]; the great models of ships built in the Cantabrian Sea by Álvaro de Bazán the old between 1540 and 1550, which I have already mentioned, among others. Between 1581 and 1582 a set of documents edited by Cristóbal de Barro was drafted, as a result of the commission made by Felipe II for the construction of a squadron of galleons for the Army of the Guard of the *Carrera de Indias*. According to Casado Soto this is the origin of the birth of the Hispanic war galleon typology for ocean navigation. In 1588 eight of these ships were part of the Gran Armada and some of them were able to return to Spain. The archaeological interventions on wrecks of this Great Navy could give us more information about this historical mystery barely outlined in the works of Colin Martin, Casado Soto, or Miguel San Claudio and in the documentation of Menéndez Avilés and Cristóbal de Barros. It has been said that most of the great galleons perished in the battles that took place during the War of Succession to the Crown of Spain between 1699 and 1714, such as the cases of the lost fleet at Rande in 1702 or the shipwreck of *San José* in Colombia. The truth is that by the end of the seventeenth century the galleon had already evolved into the shape of the ship of the line of the following century.

3 Epilogue: the consolidation of a Hispanic Naval School in the Eighteenth Century

The complete annihilation of ships during the War of Succession and a change in political direction versed in Bourbon centralization led to the unification of a royal navy, first postulated in 1704. After the war ended, the activities of Minister José Patiño y Rosales, president of the Casa de la Contratación transferred to Cádiz in 1717, the creation of the Intendency of the Navy, and the subsequent appointment of Patiño as Secretary of State were factors contributing to the reorganization of this Navy and, of course, to a revision of ship architectural regulations. It is known, as it has been well studied, how even the increasing mobilization of resources for war affected the State itself (Torres Sánchez 2013). In the treatises written by statesmen of the time such as Gerónimo de Uztáriz or Antonio de Ulloa, appears the problem of wood supply and the consolidation of a constructive style that would characterize the Spanish merchant and war fleet until the Battle of Trafalgar. José Patiño was instrumental in the naval reorganization program. He issued new ordinances for the centralization of all the navies and fleets, which were united with the exception of the Navy of Galeras and the Navy of Windward (*Armada de Barlovento)*. But in addition, he even personally took care of obtaining the financial means to ensure

[18] AGS, MPD, 16, 164

that the navy had qualified personnel, centralizing a single Royal Navy, promoting maritime commerce, establishing some ordinances: Ordenanzas of José Patiño, president of the Casa de la Contratación in 1717; *Proyecto de Flotas y Galeones* (1720), Arsenals (1723), *Cuenta y Razón* (Account and Reason) in 1725, Body of the Ministry of the Navy (1725), Enrollment of Sea (1726), Surgeons (1728), and Intendants (1735). In the eighteenth century, even the Juntas were continued, such as the Junta de Marina, established in 1715 and 1716 by Minister G. Alberoni and others, but in short, this centralized navy continued with the main objective it had since the sixteenth century: the defence of colonial trade with America. The reforms of Felipe V did nothing but to consolidate this intrinsic relationship, although now attempts were being made to reinforce the means of financing and organization that it lacked previously. In 1717, Patiño was about to open a Royal Shipyard in Cádiz, which was in charge from that moment on of managing these money inflows and the size of the ships. However, Patiño was going to leave Cádiz in a hurry and the management ended up again in the hands of Francisco de Varas and Valdés. A good part of the contemporary information on ships is contained in works related to naval and maritime trade, such as the works of Antonio de Herrera, "General history of the events of the Castilians in the lands of Tierra Firme of the Ocean Sea (*Historia general de los hechos de los castellanos en las tierras de Tierra Firme del mar océano)*", 1726; or that of Antonio de Capmany, "Appendix to the maritime customs of the book of the consulate: contains a collection of laws and statutes of Spain from the thirteenth to the eighteenth century, relating to naval trade ordinances, Historical memoirs on the navy, commerce and arts of the old city of Barcelona and Ordinances of the naval navies of the Crown of Aragon" *(Apéndice a las costumbres marítimas del libro del consulado: contiene una colección de leyes y estatutos de España desde el siglo XIII hasta el XVIII, relativos a ordenanzas de comercio naval, Memorias históricas sobre la marina, comercio y artes de la antigua ciudad de Barcelona y Ordenanzas de las Armadas navales de la Corona de Aragón).* To this is added the monopoly of some large firms of merchants, well related to the Crown, such as the Goyeneche family or the contractor Daniel Van Eden, in relation to the business of transporting wood, during the War of Succession.

The creation of the Intendance represents the culmination of José Patiño y Rosales project to turn the Bay of Cádiz into a centre of naval provision and storage as well as to redirect the benefits of trade to the construction and organization of navies (Crespo Solana 1996). Patiño's speech turns the commercial and naval revitalization plan into a preliminary draft of the national shipbuilding industry that should focus geographically on the Basque-Cantabrian areas (hence the subsequent intervention of Antonio de Gaztañeta) and Andalusia. In Cádiz, the use of such a singular geography in the double system (private and institutional) that defined the Spanish trade in the Indies came from the emergency of creating a centralized navy, created in 1704 in the awareness that trade and the empire had to be defended on both sides of the seas with a good legislative base and to replace the old position of Admiral Mayor of Castile. The latter had become a hereditary political-military appointment that had lost its naval responsibilities in the face of a more than fragmented conjunction of navies and fleets that had no common leadership. The admiralty, divided between the admirals of Castile, Granada, and the Indies, had responsibility for the navies but their evolution was very irregular and their general powers were varied or passed to other newly created positions such as that of the captain general of the Sea (1517). The connection with this preceding situation is little studied except in Calderón Ortega (2003) and Ceballos-Escalera (2012). With the Royal Decree of February 1714, all existing squads and fleets were ordered to be unified. This was reaffirmed in the legal project in June 1717 with the promulgation of Ordinances for the Navy and the installation of the General Marine Intendance in Cádiz (Crespo Solana 1996; Baudot Monroy 2012).

Several circumstances must be considered. The dilemma over whether shipbuilding expenses should be based on centralized resource management or in the form of contracts between the crown and private merchants was a problem that continued throughout the eighteenth century. This supposed a total privatization of resources and, therefore, of the ships themselves, something that evidenced the limited capacity of the Crown to have everything under control. According to Carla Rahn Phillips, only when a state is fully developed can it become a regulator of the production capacity of others (Phillips 2010). Both systems, central administration and contracts, coexisted. In fact, in the organization of arsenals and the creation of new shipyards, the strong presence of the contracting system in shipbuilding businesses is notable.

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Chapter 11
Iberian Documents and Treatises on Shipbuilding

Patricia Schwindinger, Filipe Castro, and Ana Crespo Solana

Abstract Technical texts on shipbuilding are rare before the Renaissance. The story of the evolution of watercraft in Europe in the two millennia before the appearance of the first shipbuilding treatises is regional and complex, and it is not until the fifteenth century that larger European merchantmen started converging into a small number of types, sharing the same characteristics because they were designed and built for similar functions.

1 Introduction

Small craft remained regional and the variation of boat types, shapes, and rigging can be observed in harbor scenes painted or photographed well into the twentieth century. In general, it can be said that the evolution of modern naval engineering was influenced by the processes of demand for wood, geographical organization of shipyards, construction and careening zones, and the need of the administrations to organize the navies and fleets of war and commerce. These imperatives influenced both the timber trade and the construction models themselves.

Shipbuilding treatises are an invaluable source of information, both from the descriptions and calculations they preserved and from the sometimes very accurate illustrations that codified the knowledge about the construction models. There are several types of treatises and technical texts on shipbuilding: codices, printed books, reports, contracts, and lists of dimensions or descriptions of particular types of vessels, generally large merchantmen or warships. The study of technical texts on

P. Schwindinger (✉)
Texas A & M University (TAMU), College Station, TX, USA
e-mail: pschwind@tamu.edu

F. Castro
Universidade Nova de Lisboa (UNLA), Lisbon, Portugal

A. Crespo Solana
Instituto de Historia, Consejo Superior de Investigaciones Científicas (CSIC), Madrid, Spain

A. Crespo Solana et al. (eds.), *Heritage and the Sea*,
https://doi.org/10.1007/978-3-030-86460-6_11

shipbuilding suggests that some texts are descriptive and were written by informed shipwrights, while others are prescriptive and do not necessary describe practices, but rather seem to have been written as attempts to standardize and regulate the design and construction of ships.

This paper focuses on Spanish and Portuguese texts. The earliest surviving texts, dating to the late fourteenth and the fifteenth century, were written on the shores of Mediterranean France and Italy. Some have been published, but a large body of shipbuilding texts remains on archive shelves, waiting to be read, studied, and published. In Spain and Portugal an important collection of these documents has survived and is far from being inventoried, studied, and published. Below we present some of the most important ones. Starting in the third quarter of the sixteenth century, a number of technical texts on shipbuilding, some written in the form of treatises, describe or propose recipes for the design and construction of ships in Spain and Portugal. Although both countries' politicians tried to keep a semblance of independence during the Habsburg period (1580–1640), the fact that both crowns fell on a single head intertwined both countries' policies, including their naval policies. As Francisco Contente Domingues reminds us (Contente Domingues and Ingham 1998), the study of naval history in the Iberian Peninsula has its roots in Spain, in the 1880s, on the preparations for the 400 years commemoration of Columbus' voyage to the New World, and in Portugal soon after, as a reaction to the Columbian commemoration. This circumstance, combined to the parochial nationalism of both countries during the first three quarters of the twentieth century, has perhaps influenced the development of two independent and parochial naval histories of Portugal and Spain, which does not properly reflect the relations between both countries, mostly during the dual crown period: Felipe II of Spain (k. 1556–1598) was king of Portugal (1580–1598), Felipe III was king of Spain and Portugal (1598–1621), as was Felipe IV (k. 1621–1665) from 1621 to 1640.

Although the present discussion has focused on a set of Iberian design concepts, it is important to note that two major geo-political entities, Spain and Portugal, inhabit the same mass of land, and that Spain encompassed a number of nation states separated by language, geography, and culture. Most Iberian languages were similar, but some are recognizably different. Units of measure are different from region to region and the manuscripts and treatises describe shipbuilding different types of watercraft. Some of these texts were authored or assembled by shipwrights, merchants, naval officers, or by people connected to the sea. Others were written by scholars for political purposes and do not necessarily illustrate the reality in the state shipyards of their time. Their study, compounded with the study of the legislation issued in Spain in the early seventeenth century, yields an important number of clues to our understanding of the shipbuilding world of their time, and the exchange of knowledge and ideas that characterized the cosmopolitan seafaring world. For instance, the description of a galley in Manoel Fernandez' manuscript *Livro de traças de carpintaria* (1616) uses a fair number of words of Italian origin to designate ship parts and measurements (e.g., *boca, condelata, corda, coxia, dragante, escalmo, esquife, galivar, lata, postiça*, or *tapieira*). The Italian influence on Portuguese shipbuilding is well-known, and these words only reinforce our understanding of that influence.

It is impossible to inventory all the technical texts on shipbuilding in existence in sixteenth and seventeenth century Europe, and in this chapter we present a list of the best known ones, in Spain and Portugal and give a general description of their contents (see also Vol. 1. Chap. 10). In Spain, the search of the ideal Atlantic ship was documented in the *Espejo de Navegantes*, a 1537 manuscript of Alonso de Chaves, which includes references on the characteristics of the ships. This is one of the first works related to seafaring, and it sets the tone for the following ones, at least when it comes to presenting both navigation science and shipbuilding rules in a single book. Most works focused on shipbuilding appeared in the second half of the sixteenth century. Spanish ships are described in several late sixteenth and early seventeenth century texts, some of which contain detailed information. The best descriptions are collectively presented in the three manuscripts by Jhoan Escalante de Mendoza, *Itinerario de Navegacion de los Mares y Tierras Occidentales* (1575), Tomé Cano's *Arte para Fabricar, Fortificar y Apareiar Naos* (1611), and Diego García de Palacio, *Instrucion nautica para el buen uso de las naos, su traça, y gobierno conforme à la altura de Mexico* (1587, facsimile publication 2007). A large number of manuscripts still unpublished, in combination with three sets of legislation known as the *Ordenanzas* of 1607, 1613, and 1618 form the main body of Spanish ship architectural documentation (Rahn-Phillips 1987, 1993). In Portugal, where the Indiamen were designed for a voyage of six to eight months across three oceans, ships were necessarily larger than their Spanish equivalents. In both shipbuilding traditions vessel size appears to have consistently increased during the first part of the sixteenth century (Costa Valente 1996). By 1571 the capacity of Indiamen was fixed between 350 and 500 tons burden, but we do not know how this capacity was calculated. Portuguese shipbuilding treatises describing vessels from the late sixteenth and early seventeenth centuries contain detailed illustrations and information. The most extensive are the two treatises of Fernando Oliveira, *Ars Nautica* (1570) and *Livro da fabrica das naus* (1580). The works of João Baptista Lavanha's *Livro primeiro de arquitectura naval* (c.1610) and Manoel Fernandez' *Livro de traças de carpintaria* (1616) are also important and informative documents (Rahn-Phillips 2000; Domingues 2004). They all indicate that a capacity between 500- and 600-tons burden was the optimum size for the India Route or *Carreira da Índia* ships. Historical records suggest that the ships intended for the India route were larger than the ships built for and sailed in the European, Mediterranean, and African trade. Sailing routes between the Iberian Peninsula and northern Europe, the Mediterranean, the western coast of Africa, or Brazil were generally shorter than routes to the East Indies. Despite the continuous stream of state incentives for the construction of ships over 100 *toneladas* for the Atlantic and Mediterranean trade routes, some dating back as far as 1470, small traders still averaged between 40 and 100 *toneladas* as late as the mid-sixteenth century.

2 Tonnage and Units

Although modern calculations of early Spanish ship tonnage is a difficult subject, ships' sizes were well documented, both in Spain and in Portugal (Casado Soto 1991). The sizeable sample of registered ship sizes reveals that Spanish *naos* for the

Carrera de India during the first half of the sixteenth century averaged around 100 metrics tons burden, or close to 200 metric tons displacement. They doubled their size, on average, during the second half of that century (Pérez-Mallaína Bueno 1998). The trend towards growth of the merchantmen's sizes, felt during the sixteenth century, seems to have encountered opposition in the beginning of the seventeenth century, and efforts were made to standardize ship shapes and sizes (Barcelos 1898; Costa 1997). In 1575 Juan Escalante de Mendoza mentions in his treatise on navigation *naos* of 500 tons burden as the best fit for the New World route (Escalante de Mendoza 1985). Soon after, in 1587, Diego Garcia de Palacio states that 400 tons burden is a good size for commerce and war (García de Palacio 1587).

The *Ordenanzas* of 1607 created legislation, which applied to both Spanish and Portuguese merchantmen with capacities between 150- and 250-tons burden. The *Ordenanzas* also defined the functions of larger vessels: *galeonzetes* of approximately 300 to 500 tons were intended as ships of war, as were *galleons* with capacities between 550 and 750 tons. In 1611, Tomé Cano described a *nao* measuring 12 *codos* in breadth as having a capacity of 232 tons (Cano 1611). The important factor is that the proportions of these vessels did not vary much between vessels of different sizes (Rahn-Phillips 1993). In Spain, formulas were utilized to calculate a ship's capacity since the middle of the sixteenth century, and it was likely the same in Portugal (Casado Soto 1991). However, historical documents mention a practical system in use in Portugal, in which officers would come aboard with a number of hoops and gauges and estimate the real number of barrels that would effectively fit in the ship's hold (Costa Valente 1996).

As published elsewhere (Castro 2013), the Portuguese used a unit of linear measurement, possibly imported from Genoa, designated the *goa* or *côvado real* and equivalent to 77 cm. It was related to a local unit designated the *vara*, of which a standard offered by king Sebastian (1554–1578) to the city of Tomar measured exactly 110 cm. A *goa* was divided into 3 *palmos de goa* (25.66 cm) of 7 *polegadas* (3.67 cm) or 14 *dedos* (1.83 cm) each. The *vara* was divided into 5 *palmos de vara* (22 cm) of 6 *polegadas* or 12 *dedos* each. The *goa* was the equivalent to half a *rumo* (1.54 m), the height of the standard *tonel*, which was the unit of capacity in use in Portuguese shipyards. The maximum diameter of this standard *tonel* was 4 *palmos de goa* (1.027 m), and its capacity was twice that of a *pipa* and four times the capacity of one *quarto* (Barreiros 1838; Barata 1996; Costa 1997).

The exterior volume of the cylinder that contains this *tonel* is given by:

$$\pi \times {r_{\max}}^2 \times h = 1.276 m^3. \tag{11.1}$$

With π = 3.14159, r = 1.027/2 = 0.51 m, and h = 1.54 m. Kepler established a method to calculate a barrel's capacity considering the curvature of its sides elliptical:

$$1/3 \times \pi \times h \times \left(2{r_{\max}}^2 + {r_{base}}^2\right) \tag{11.2}$$

or parabolic:

$$1/15 \times \pi \times h \times \left(3r_{base}^{\ \ 2} + 4r_{base} x r_{\max} + 8r_{\max}^{\ \ 2}\right) \quad (11.3)$$

where $\pi = 3.14159$, r_{max} is the maximum radius, r_{base} is the radius of the barrel's base, and h is the height of the barrel.

The values obtained through eqs. [11.2] and [11.3] are similar, but to obtain them we need to estimate the radius of the barrel's base, the thickness of the staves and heads, and the height of the chimes. Data pertaining to the dimensions of barrel staves are scarce, but there are no strong reasons to suppose that these have changed drastically over the centuries. For lack of a better plausible source relating the thickness of barrel staves and the size of the barrels we have used late nineteenth century values and assumed that the thickness of barrels' staves and heads was 4 cm and the chimes 5 cm. In this case, the maximum interior diameter becomes 94 cm and the interior height 1.36 m.[1] Varying the diameter of the base between 80% and 95% of the maximum diameter, the capacities obtained with eqs. [11.2] and [11.3] present differences smaller than 1%. For diameters of the base equal to 80%, 85%, 90%, and 95% of the maximum diameter of the barrel, the elliptical model determines capacities of 831, 857, 884, and 913 liters and the parabolic 828, 855, 883, and 913 liters, respectively.

In a collection of *barricas*—in Portuguese *quartos*—found on the Basque whaler *San Juan*, lost in 1565 at Red Bay, Canada, and carefully studied by Brad Loewen, the average relation between the diameters of the base and the bilge (maximum value) was 89% (Loewen 1999). Considering this value, the calculated capacities are 878 and 877 liters for elliptic and parabolic sides, respectively, not far from the 52 *almudes* (873.6 liters) traditionally referred to in the literature, at least if we accept the value of one *almude* as 16.8 liters (Lopes 2003).

In Spain the linear unit in use in shipyards was the *codo*, with two different values in the beginning of the sixteenth century: the *codo andaluz* or *castellano* (55.7 cm), equal to 2 *pies* (27.85 cm), 24 *pulgadas* (2.32 cm), and 32 *dedos* (1.74 cm), and the *codo cantábrico* or *de ribera* (57.5 cm), equal to 33 *dedos castellanos*. The *codo andaluz* equaled 2/3 of a *vara castellana*, which was equivalent to the *goa andaluz* (83.6 cm). The *tonel* was a unit of volume equal to 2 *pipas* and 8 cubic *codos*. When the *codos* considered in the composition of a *tonel* were *castellanos* the *tonel* was designated as *tonelada de carga* (1.382 m^3). When the *tonel* was composed of 8 cubic *codos cantábricos*, it was designated *tonel macho* (1.521 m^3). The capacity of a *tonel* is difficult to establish. Juan Escalante de Mendoza indicates 55 *arrobas* in 1575, or 632.5 liters, if we consider one *arroba* equal to 11.5 Kg (Fernández Duro 1880a; Rodríguez Mendoza 2008a, b).

[1] Special Consular Reports, Vol. 7.1, The Stave Trade in Foreign Countries, 1891–1892. Government Printing Office, Washington, pp. 3–89.

Table 11.1 Spanish and Portuguese Shipbuilding Units in the Sixteenth Century

Unit	Metric System Equivalent	Country
Codo castellano	55.7 cm	Spain
Codo cantabrico	57.5 cm	Spain
Vara castellana	83.6 cm	Spain
Palmo	20.9 cm	Spain
Dedo	1.74 cm	Spain
Tonelada de carga	1.382 m^3	Spain
Tonel macho	1.521 m^3	Spain
Rumo	154 cm	Portugal
Goa	77 cm	Portugal
Palmo de Goa	25.667 cm	Portugal
Vara	220 cm	Portugal
Palmo de vara	22 cm	Portugal
Dedo	1.83 cm	Portugal
Tonel	1.275 m^3	Portugal

Curiously, the *Enciclopedia general de la mar* indicates 436 *liters* as the capacity of a *pipa de Castilla*, making the Castillian *tonel* 872 *liters*, very close to the Portuguese one, of 877 or 878 *liters* (Martínez-Hidalgo 1982; Rubio Serrano 1988).

When a ship was freighted, the payment was calculated by the state or the private freighter in *toneladas de sueldo*, which corresponded to the ship's capacity calculated in either *toneladas de carga* or *toneles machos*, plus 20 or 25% of that volume, to account for the space occupied by the crew, victuals, spares, and equipment (Casado Soto 1988).

These units of measurement were certainly used in Iberian shipyards, but we should not expect them to be applied with too much zeal. Shipwrights have to build with the materials they have at hand, and archeologists should not expect to find archeological timbers fashioned to the precision of a *dedo* (Table 11.1).

Sources: (Casado Soto 1988; Castro 2005).

3 Catalogue of Iberian Texts

Below is a catalogue of the most important Iberian technical texts on shipbuilding from 1550 to 1650.

***Ars Náutica*, c. 1570.**

Author: Fernando Oliveira.

Country: Portugal.

Language: Latin.

Location: Leiden University Library, Leiden, Netherlands.

- Call No.: Ms. Voss. LAT. F. 41 (*Codices Vossiani Latini* in folio).
- Notes: In the *Ex Bibliotheca Viri Illustris Isaaci Vossii*, under the title *Ferd. Oliverii de S. Columba Ars nautica*. - *Viagge de Ferdinando de Magalhones.*

Publications: The work remains unpublished, but some illustrations from it were published in the late seventeenth and twentieth centuries. See Reith, Eric. "Remarques sur une série d'illustrations de L'Ars Nautica de Fernando Oliveira," Paris: *Neptunia* (Rieth 1988).

Description: This manuscript was authored by a Portuguese priest named Fernando Oliveira ca. 1570. It is the longest of Oliveira's works, a complete treatise on all of the technical aspects of navigation. It was written for scholars and not as a practical treatise for navigators, as evidenced by the use of Latin and by the type of navigation it discusses. It received little attention at the time and was never published in its entirety. Its illustrations were published several times, including in Witsen's 1671 *Aeloude en Hedendaegsche Scheeps-bouw en Bestier* (Hoving et al. 2012). Leiden University acquired the manuscript in 1710. It remained unknown to Portuguese historiography until 1960 (Domingues 2004).

About the author: Fernando Oliveira was born c. 1507 in Aveiro, a coastal city with a long maritime tradition. He entered the Dominican Order at the age of nine or ten. He studied in Évora, where he may have been the pupil of a well-known humanist, André de Resende, who had studied in Spain with Antonio de Nebrija, the author of the first Spanish grammar. Oliveira left the Dominicans around the age of twenty-five, in 1532. He later published the first Portuguese grammar, in 1536. This book was followed by other scripts, among which are: *Arte da Guerra no Mar* (1555), *Ars nautica* (1570, in Latin), *Livro da fabrica das naus* (c. 1580), and a history of Portugal. *Ars Nautica* was compiled from previous notes, as he explains in *Arte da Guerra no Mar*, but these are probably lost (Lopes de Mendonça 1898; Barker 1992; Domingues 2000, 2004).

He had an adventurous life as a sea pilot and political mediator. It is not known how or when he acquired the skills to become a pilot. In the late thirties or early forties, the French captured him while he was sailing from Barcelona to Genoa. He ended up working for François I in his fleet of war galleys, which was stationed in Marseille. He later returned to Lisbon, perhaps in 1542. In 1545, he enlisted again in the French navy as a pilot of one of the galleys sailing to England. He may have witnessed the demise of the English ship *Mary Rose*, sunk by the French. In 1547, he was arrested by the Holy Inquisition. He spent two years in the Inquisition dungeons. In 1552, during a Portuguese mission, he was made prisoner in the north of Africa. He then returned to Portugal where he was again arrested by the Holy Inquisition. Despite spending at least another two years in their jail, from 1555 onward Oliveira seems to have settled and stayed in Portugal. He turned down invitations to work for the French and Spanish navies in the late 1560s. He died after 1581, probably around 1585, and possibly outside of Portugal (Domingues 2000, 2004).

Content: The manuscript is divided into three parts:

I. De quibusdam instrumentis ad primam nautarum institutionem conducentibus.

This section focuses on the art of sailing itself, with special attention to how charts and navigational instruments are made and used.

II. De nauipegia, & ejus adminiculus.

The second section focuses on naval architecture and represents the first work from Portugal on this topic. Although all the drawings in the work are of round ships, the text itself focuses more on galleys. Of particular note are his illustrations of the cross-section of the ship, a novel style of depiction that was not adopted by other shipwrights for several centuries, although it is now standard. Nicolaas Witsen, a seventeenth century Dutch shipwright, was so taken with the drawings that he traced them and reprinted them in his own writing (where the images appear reversed from the original).

III. De officio nautarum.

The final section addresses the logistical and administrative matters of the navy. It deals with material he had already written about in a broader context and scope in *Arte da Guerra no Mar* (Domingues 1985, 2000, 2004, 2009; Rieth 1988; Pereira 2009; Hoving et al. 2012).

***Itinerario de Navegación de los Mares y Tierras Occidentales,* 1575.**

Author: Juan Escalante de Mendoza.

Country: Spain.

Language: Spanish.

Location: Original manuscript copy, with revisions, held at Biblioteca Nacional de España, Madrid, Spain.

- Call No.: Codice J 156 (Mss 3104) in Biblioteca Nacional de España.
- Notes: The maps from the work are held in the Museo Naval (Lamb 1995).

Publications: The work was republished several times (González-Aller Hierro 1998). The 1880 printing of the work in Volume 5 of Duro's *Disquisiciones náuticas* is perhaps the most readily available version, and there is also a 1996 reprint in facsimile of Disquisiciones náuticas produced by the Ministerio de Defensa, Instituto de Historia y Cultura Naval (Fernández Duro 1880a, 1996).

Description: *Itinerario de Navegación de los Mares y Tierras Occidentales* is the oldest known text in the Spanish language to discuss shipbuilding. It is written as a dialogue "in the manner of the serious Greek and Latin philosophers," as the author describes it. The main dialogue takes place between two people: an experienced pilot and a person learned in the art of navigation.

About the author: Asturian by birth, Jhoan de Escalante de Mendoza was captain general of the New Spain fleet in 1595. He was the son of García de Escalante and Johana de Mendoza. He was born around 1530 in Valle de Riva de Deva in the province of Santander, Spain. At a young age he went to live with his uncle, Álvaro de Colombres, a ship's captain who instructed him in the art of navigation. At eighteen years of age, he captained his own ship on a round trip voyage to Honduras. He dedicated his career to the *carrera de las Indias* (literally, the Indies run), reaching the position of capitán general de la flota de Nueva España (captain general of the

New Spain fleet) in 1595. He died in 1596 in the city of Nombre de Dios (Fernández Duro 1880a).

Content: The work is divided into three books. The first book describes the route down the Guadalquivir river from Seville to Sanlúcar de Barrameda and contains a treatise on naval architecture. The second book explains how to navigate from the mouth of the Guadalquivir to the Gulf of Vera Cruz (for the fleet of Nueva España) and to Nombre de Dios (for the fleet of Tierra Firme). It also discusses nautical instruments, how to measure latitude, and meteorology. The third book details the return voyage to Spain and includes discussion on: compensating for magnetic declination, San Telmo's (Saint Elmo's) fire, seasickness, shipwrecks, and privateers, among other topics (Fernández Duro 1880a).

Livro da fabrica das naus, c. 1580.

Author: Fernando Oliveira.

Country: Portugal.

Language: Portuguese.

Location: Biblioteca Nacional de Portugal (BNP), Lisbon, Portugal.

- Call No.: COD 3702.
- Notes: This book is written with an unvulgar clarity and describes in detail the design of an India *nau* of 600 tons, detailing all the important measurements and design procedures.

Publications: A digitized version of the original can be accessed through the BNP: http://purl.pt/6744

Description: The *Liuro da Fabrica das Naus* has been dated to 1580 and is the earliest surviving treatise for which the main focus is shipbuilding. It is also the earliest known shipbuilding text in the Portuguese language. It expands extensively on Oliveira's earlier treatise, *Ars Nautica*, which was written in Latin and included only a section on naval architecture. The *Liuro* is a theoretical work written by a scholar and not a practical work by a practicing shipwright (Oliveira 1991, 1995; Rieth 1988).

About the author: See entry for *Ars Nautica* of 1570.

Content: The *Liuro da Fabrica das Naus* is comprised of a clear text with a few illustrations. It is, unfortunately, incomplete. It describes a 600-ton nau da India, a ship designed to endure the six-month voyage from Lisbon to the Indian subcontinent, and the return trip, in which these vessels were loaded with as much merchandise as possible.

As it survived, it is divided into nine chapters.

Prólogo.

1 – Da antiguidade das naus.

2 – Das madeiras convenientes para a fábrica das naus.

3 – Do tempo em que se devem colher as madeiras e da maneira que se deve ter em as colher.

4 – Dos achegos da fabrica naual.

5 – De quantos generos, e maneyras de nauios ha na arte da nauegação: e dos nomes delles.

6 – Que he necessaria arte na fabrica das naos, e diz que cousa he arte.

7 – De como a arte na fabrica das naos imita, ou arremeda a natureza dalgus peyxes, e animaes.

8 – Da fabrica, e medidas das naos de carrega.

9 – Dos aparelhos necessarios para os nauios de carrega.

Oliveira defines the dimensions of the primary structural components of a ship—stem, stern post, midship, and tail frames—as simple proportions of the length of the keel. He then describes the use of algorithms similar to the ones described by Timbotta (such as the mezzaluna or the incremental triangle) to calculate the narrowing and rising of the floor timbers in the central portion of the hull. The "central portion of the hull" here means the section between the tail frames (almogamas), which are the first and the last of the pre-designed frames of a vessel (Domingues 1985, 2004; Cook 2011).

***Livro Náutico, ou Meio Practico de Construcão de Navios e Galés Antigas (Vol 1), e Memorial de Várias Cousas Importantes (Vol 2),* 1585–1595.**

Author: Unknown.

Country: Portugal.

Language: Portuguese.

Location: Biblioteca Nacional de Portugal, Lisboa, Portugal.

- Call No.: Vol 1: COD 2257; Vol 2: COD. 637.
- Notes: The two volumes were originally bound as a single volume.

Publications: A digitized version of the original can be accessed through the BNP: http://purl.pt/13907. The work was transcribed and published as an appendix (Lopes de Mendonça 1892).

Description: The *Livro náutico* is a collection of manuscripts bound in two volumes, with 86 and 144 pages, respectively, dating between 1575 and 1625. It contains important data pertaining to the organization of the part of the Spanish Armada of 1588 that was fitted in Lisbon, as well as several lists containing armament and victuals for India naus. Francisco Contente Domingues dates the compilation to the late 1580s/early 1590s, placing it between the work of Fernando Oliveira and João Baptista Lavanha. Other estimates for the date of the work range from 1575 to 1625.

The book was originally bound as a single volume, but at some point, was split and rebound as two volumes. The works got separated, so that for a long time the second volume, *Memorial de Várias Cousas Importantes*, was not recognized as being associated with the *Livro Nautica*. A plate in the back of *Memorial* states that the *Livro «contém a primeira parte deste códice»* (contains the first part of this codex) (Domingues 2004).

Content: The documents compiled in the *Livro* include detailed lists of measurements, quantities of wood, and total costs needed for building various ships; salaries and supplies needed to man the vessels; ammunition, artillery, weapon, and gunpowder lists and costs; and the total value of certain vessels as well as the total value of the 1588 Spanish Armada. The *Memorial*, in addition, contains a more diverse set of documents: the costs and income from various parts of the Portuguese empire, including India, Brazil, Mina, Santo Thome, Cape Verde, and Angola; construction and maintenance of various sizes of vessels; supplies needed and their costs; and technical navigation issues.

Of particular note is the «*Folha dos Nauios que Sua Magestade tem nesta Coroa de Portugall…*» ("List of the Ships that His Majesty has in this Crown of Portugal…"). It is a list of ships available for Crown use in 1589, including their current state of readiness and the cost of getting them rigged and ready to set sail, including artillery but not wages. It begins in the Livro and continues in the Memorial. There is also a list of ships, men, weapons, ammunition, and other supplies «*que se entienden ser menester para en caso que se haya de hazer la jornada de Inglaterra*» ("which are understood to be necessary in the event that the day of England is to be carried out"), including an estimate of the cost of outfitting the expedition and paying those involved for eight months (p 80–104 in Memorial) (Lopes de Mendonça 1892, 1898; da Fonseca 1938; Domingues 2004).

***Instrucion nauthica para el buen uso, y regimiento de las Naos, su traça, y gouierno conforme à la altura de Mexico,* 1587.**

Author: Diego García de Palacio.

Country: Spain (Mexico).

Language: Spanish.

Location: The work was published in 1587. A number of original copies exist, including but not limited to:

Mexico: Biblioteca Cervantina, Monterrey.

Spain: El Escorial and Museo Naval, Madrid. Universidad de Salamanca, Salamanca.

Great Britain: The British Library, London.

United States: New York Public Library and Hispanic Society of America, New York City, and Huntington Library, Huntington, NY; John Carter Brown Library, Providence, RI; Library of Congress, Washington, D.C.; Yale University, New Haven, CT.

Publications: A digitized version of the first edition copy held by the Library of Congress can be viewed here: http://hdl.loc.gov/loc.rbc/SpanishAmerican.13311.1. There are a few editions, translations, and transcriptions that have been published (García de Palacio 1944; García de Palacio 1986; Cuesta Domingo 1993; González-Aller Hierro 1998; García de Palacio 2007). There are also partial reprints in Fernández Duro's *Disquisiciones Náuticas (Fernández Duro* 1880b) and an excerpt in Trabulse's *Historia de la Ciencia en México (Trabulse* 1985). Lastly, there is a possible reprint of the glossary in the *Vocabulario marítimo, y explicación de los vocablos, que usa la gente de mar, en su exercicio del arte de marear* (Fernández de Gamboa 1722).

Description: *Instrucion nautica* was the first volume on shipbuilding to be published by a printing press, possibly because it was included in a broader work on navigation (navigation was the second most common topic in published books in sixteenth century Spain, second only to medicine). It contains the first printed pictures related to shipbuilding. The manuscript was written by Diego García de Palacio, a navigator and colonial administrator. He oversaw the construction of a few ships in the Americas, but he was not a shipwright. The text takes the form of a dialogue between a *vizicaíno* (person from the province of Biscay) who asks questions and a *montañés* (literally, "person from the mountains") who is an expert in shipbuilding. Its style and the inclusion of a glossary suggest that it was intended for non-specialists.

About the author: Diego García de Palacio was born around 1542. He was the eldest son of Pero García de Palacio and María Sanz de Arce. He studied in Salamanca and Valladolid, an education that culminated in a *licenciatura* in law, an advanced degree that virtually guaranteed a secure and influential post in the civil service. By 1567 he had obtained an official post in Spain. He married Isabel de Hoyo Solórzano, the niece of King Charles V's royal secretary, and they had at least four children.

In 1572 he was appointed as an *oidor* (civil court judge) in Guatemala. He arrived there in 1574 or 1575, having encountered some difficulties in securing transportation. In 1577 he arrived in El Realejo, a port on the Pacific coast of Nicaragua with several established shipyards, many owned by Genoese shipbuilders. There he was responsible for overseeing the construction of two Manila galleons, from which he gained his technical knowledge on shipbuilding in the Americas. He served in several other positions in Mexico afterwards.

In the course of his travels and service in Mexico and Central America, he wrote several very detailed accounts of the indigenous people, native cultures, Mayan ruins, and maritime trade of the area. These were sent directly to King Philip II. He also wrote and had printed two books, *Diálogos militares* and *Instrucción náutica*. Historians have found his accounts of native culture and nautical practices to be notably accurate and reliable.

His career, however, was checkered. He initially built a strong reputation, based solely on his writing, as knowledgeable in naval and military matters. He once offered to conquer the Philippines at personal expense in return for a monopoly on the Manila-Acapulco route. But he never participated in any actual conflicts; even when ordered to do so, he made excuses and delays to avoid any combat. He used his official positions in Mexico to siphon money and appointments for himself and his family members. The two ships he was overseeing, for example, were not completed until 1582, three years behind schedule and at an outrageous cost of 46,000 pesos a piece (they could have been built in Manila for only 6000 pesos each). One of the ships, the *San Martín*, was then auctioned off by the viceroy to García's brother, Lope de Palacio, for 16,000 pesos, and used for private trade.

His embezzlement did not go unnoticed, and he was eventually convicted on numerous counts of corruption, including nepotism, accepting bribes, making threats, exploiting his office for his own financial benefit and for the benefit of his family, displacing native communities, and forcing the locals to work without pay. His first conviction in 1586 had little effect, as he still enjoyed the favor of the local viceroy, but in 1589 he was convicted again and suspended for nine years. He passed away in 1595 without resuming office (Laanela 2008).

Content: The first three of its four books deal with navigation, astronomy, and astrology. They are notable among navigational texts for having dates calculated in the Gregorian calendar (which was introduced in 1582) and for including the latitudes of Mexico. The work begins with a chapter on the celestial and terrestrial spheres, describing their nature and number. Following this is a description of the division of the Earth's sphere according to latitude and longitude and the position of the poles and the equator. The nautical compass (or *brújula seca*), the quadrant, the astrolabe, and the *ballestilla* (or *crúz geométrica*) are discussed. There are also instructions for calculating the hours of the day. The second chapter describes astronomical phenomena as they appear in tables and almanacs, followed by an exposition of the movements of the sun and the moon, the conjunctions of the planets, and the regularity of the tides. The tables are calculated for the latitude of Mexico City, with an implicit orientation to the Pacific. In the third book the author deals with astrology (*astrología rústica*) or movements of the stars that affect the person. This part also includes explanations concerning nautical charts and moon tables.

The fourth book discusses shipbuilding. It focuses mainly on the construction of a *nao* of 400 *toneladas*, which follows the traditional proportions of 1 beam (breadth) to 2 keel length to 3 overall length. The section also describes, in less detail, a ship of 150 *toneladas*. It includes a discussion of the layout of the ships, their shape and proportions, what complement of crew they need, and how they are used in naval combat. It finishes with a glossary of more than five hundred terms. The shipbuilding instructions are quite thorough, containing all information needed, according to Bankston, for a shipwright to build a ship (Arróniz 1980; García de Palacio 1986; Manzano Baena 2003; Laanela 2006, 2008; Burdick 2009; Trejo Rivera 2009).

***Harvard Codices,* 1588–1633.**

Author: D. António de Ataíde.

Country: Portugal.

Language: Spanish and Portuguese.

Location: Houghton Library, Harvard University, Connecticut, USA.

- Call No.: MS Port 4794.
- Notes: 3 vols. (200, 347, 162 pages).

Publications: The codices remain unpublished.

Description: This is a collection of 162 documents, bound in three volumes, about Portuguese naval affairs and maritime expeditions. It was compiled by D. António de Ataíde, a sixteenth century naval officer and political appointee. Over his lifetime, he amassed a vast library of documents and codices pertaining to naval affairs. Charles Ralph Boxer has published a relation of Ataíde's most important documents. The three codices existing at Harvard University are unpublished but have been described by Francisco Contente Domingues (Domingues 2004).

The three volumes are titled:

1. Armadas. *Collecção de documentos, impressos e manuscriptos relativos às armadas de Portugal: / Aramadas. Collection of documents, printed and manuscript, related to the armadas of Portugal.*
2. *Collecção de varios Documentos, e papeis Regios e administrativos respectivos, e abre com um documento raro: um dos dois únicos exemplares conhecidos, em perfeito estado, da relação da Armada de 1588 dada à estampa por Antonio*

Alvarez, em Lisboa, nesse mesmo ano. / Collection of various Documents, and papers Royal and administrative, respectively, opening with a rare document: one of the only two known copies, in perfect condition, of the list of the 1588 Armada given to the press by Antonio Alvarez, in Lisbon, in the same year.

3. (Untitled) A book with copies of important documents pertaining to Ataíde's life.

About the author: D. António de Ataíde, first Count of Castro Daire, had a long and accomplished naval and political career. He was born in 1567. At age twenty, he participated in the naval expedition of the Marquês de Santa Cruz to the island of Terceira. Upon returning, he served under Don Martinho de Rivera, General of the Galleys of Spain. He worked his way up the ranks, serving variously as Captain of Horse, Frontier commander of Alcobaça, General of the Armada of the Coast, and Colonel of Infantry. From 1611 to 1612 he was Captain Major of the Indian Fleets and undertook a round trip voyage from Lisbon to Goa. In 1618 he became Captain General of the Portuguese Home Fleet until 1622, when he was relieved of command following the capture of *Nossa Senhora da Conceição* by Algerine warships. Subsequent investigations absolved him of blame.

He moved into politics, serving as Gentleman of the Chamber of Philip IV, King of Spain, and Steward to Queen Isabella and Councilor of the State Council of Portugal; President of the Council of Aragon. In 1629 he was appointed Ambassador Extraordinary to Ferndiand II, Holy Roman Emperor. From 1631 to 1633 he served, along with the Conde de Vale de Reis, as joint Governor of Portugal under the Spanish Crown. He also served as President of the Board of Conscience and Military Orders. In 1641, during the Portuguese Restoration War, he was imprisoned on suspicion of involvement with pro-Spanish activities. He was later acquitted and released. He died in 1647, leaving his collection of books and manuscripts to his cousins. The collection was dispersed in 1878–1879, when it was sold at auction (Domingues 2004).

Content: The three volumes contain a diverse set of documents, and many are original manuscripts. They are bound in three volumes. We have made an attempt to provide a brief overview here of the most significant documents included, following Boxer (Boxer 1984a), but see that article for a more complete account of the contents of the documents.

The first volume contains detailed lists, specifications, and contracts regarding the cost and manner of outfitting, arming, and supplying vessels and armadas, mostly in the late 1620s and early 1630s. Specific lists include the arming of the squadron of galleons that sailed from Cadiz in 1629; the ships, men, munitions, and supplies of the 1588 armada against England, the 1624 armada to recapture Bahia, and 1631 expeditions to Pernambouco. It also contains the cost of supplying, outfitting, and paying the crew of two East Indiamen, the *São Bartholomeu* and the *Santa Helena* in 1629, the deed of sale of a galleon (1628), contracts from Masibradi's fleet (1631–1633), instructions for fitting out an India fleet (1628), estimates of the costs of fitting out two galleons and two carracks (date not specified), and a detailed estimate of the cost for careening and refitting the *Na Sra de la Concepción* (1629). In addition, it contains tables for fitting masts to ships of 800 to 1000 tons.

The second volume contains many additional documents on the Spanish and Portuguese armadas outfitted between 1580 and 1621; documents and regulations related to trade in the East and West Indies and life on board Portuguese ships during this time period; and regulations on the construction of Portuguese and Spanish ships. It opens with a complete copy of the order of battle for the 1588 Armada. It then goes on to provide a series of printed instructions for masters and pursers of ships engaged in trade with the East and West Indies, including a detailed Portuguese set of instructions from Ataíde's voyage to Goa in 1611. It also contains a diverse set of documents relating to the operation of and daily life on board trading ships, including a method of lading spices, the allotment of space aboard ships, precautions against fire, and many others. It also contains copies of several regulations in the 1500s regarding the trade in spices, including the *liberdades* allotted to crew members and passengers by rank. There is a set of manuscripts relating to the loss of the *Conceição* in 1621 and the legal proceedings against Ataíde that resulted from it. Lastly, the final 130 pages contain the particulars of various Spanish and Portuguese armadas outfitted between 1580 and 1621.

Of most interest here are two documents related to shipbuilding: a manuscript copy of the 1578 Portuguese Regulations and the Spanish 1618 Ordinance on ship construction. The Portuguese Regulations contain instructions on the construction of ships, carracks, and galleons. The copy of the 1618 Ordinance is copiously annotated by Ataíde with the conversions from the Spanish measurements to their Portuguese and Indo-Portuguese equivalents.

The third volume opens with a copy of Ataíde's patent as Captain General of the Armada of the Crown of Portugal in 1618 and then proceeds with a compilation of letters, reports, orders, daily states, etc. of the three armadas Ataíde commanded between 1618 and 1620. The collection is so complete that Boxer notes that the movements of the ships and the events on board can be followed almost day-by-day. The volume also contains Spanish intelligence related to English naval preparations in 1620 (Boxer 1934, 1984b; da Fonseca 1938; Leitão and de Ataide 1958; Domingues and Guerreiro 1987; Domingues 2000).

***Regimentos Especias: Naos da India,* 1598.**

• *«Traça de uma nao para a India ordenada por Gonçalo Roiz, conforme a nao conceição Portugal»* and**• *«Traça de uma Nao da India ordenada por Sebastião Themudo»*.**

Author: Gonçalo Roiz (aka Gonçalo Rodrigues) and Sebastião Themudo**.**

Country: Portugal.

Language: Portuguese.

Location: Real Academia de la História – Madrid, Colecção Salazar e Castro.

- Call No. (Roiz): Cod. 9/1068 fls.14–15.
- Call No. (Themudo): Cod. 9/1068 fls. 16–17.

Notes: These are just two of a number of existing contracts that have not yet been transcribed and published (Barata 1989).

Description: These two documents are the only known examples of *Regimentos Speciais* (Special Rules) detailing the architecture of specific ships, as opposed to

Regimentos Generais (General Rules), which detailed the rules for the construction of a type of ship. Both of these documents were written in 1598 and concern the construction of Indian *naos*, although they were written by different authors. Both works contain João Baptista Lavanha's signature in addition to that of their authors, although there is no discussion of co-authorship in the text. It is possible he reviewed or certified the work in some capacity (Esteves 2011).

About the authors: Sebastião Themudo and Gonçalo Roiz (Gonçalo Rodrigues) were the *Mestres de Ribeira*, or the master shipwrights responsible for overseeing the design and construction of ships commissioned on behalf of the king in Ribeira. They were jointly appointed to the position in 1607, after the king received requests from both of them for the appointment. Following Themudo's death, Roiz was appointed to the position alone and was given a salary of 30,000 reis per year, with an additional 2000 reis for each *nau* or *navio de gávea* that was launched without mishap. For comparison, a shipwright building ships for the Carreira da India in the first quarter of the seventeenth century earned 19,200 *reis* per year, with an additional 4000 *reis* de *quintalada* (Esteves 2011).

Content: These two short documents contain recipes for the construction of two India naus, with measurements and geometrical considerations (Barata 1989; Hernani Amaral 1992; Esteves 2011; Kapp 2018).

***Livro primeiro de arquitectura naval,* c. 1600.**

Author: João Baptista Lavanha.

Country: Portugal.

Language: Portuguese.

Location: Biblioteca de la Real Academia de Historia, Madrid, Spain.

- Call No.: Col. Salazar y Castro; COD. 63; Fls. 41–78.
- Notes: Manuscript bound in a larger codex, 27,5 x 20 cm, composed of 12 chapters, incomplete.

Publications: (Barata 1996; Domingues and Barker 1996).

Description: The *Livro Primeiro de Arquitectura Naval* has been dated to around 1600 and is generally considered to have been written by João Baptista Lavanha, the Chief Engineer and Chief Cosmographer of the kingdom of Portugal at that time. It is a theoretical work written by a scholar and not a practical text by a shipwright. It deals only with one type of vessel: the four-decked *nau* for the India Route. It is clearly more modern than Oliveira's *Liuro da Fabrica das Naus*, as it bases the design of the hull on paper drawings. Nevertheless, Lavanha calls for the need to pre-design a central portion of the hull, although only for five frames forward and abaft the midship section. The importance of this treatise lies in its accurate description of construction techniques, and in its detailed illustrations. It is incomplete, ending abruptly in the beginning of a description of the drawing of plans.

About the author: João Baptista Lavanha was born sometime in the middle of the sixteenth century, before 1555, probably in Lisbon. He was the mathematics teacher for King Sebastian of Portugal and, after the unification of the Portuguese and Spanish crowns, also of Kings Filipe II, III, and IV. In 1582, two years after Filipe II entered Lisbon as the new king of Portugal, Lavanha was appointed as a lecturer at the newly formed Academy of Mathematics in Madrid. He was also appointed to "read mathematics" in the King's court. His salary was nearly double the typical salary of university faculty chairs at the time (Domingues and Barker 1996). His responsibilities included matters of cosmography, geography, and topography. He oversaw the translation of some of the most important classical works on cosmography and mathematics into the Spanish language, so that they could be studied and used by working pilots and others in technical trades who did not know Latin. In 1586 he was named Engineer of the Realm. Based on documents bound as part of the *Livro primeiro*, his duties appear to have included evaluating the proposals for ship construction in Lisbon, and it was in this context that he wrote the unfinished manuscript. In 1602, he was appointed Chief Cosmographer of the King in Lisbon, and among other duties, he administered the exams for ships' pilots. After Philip III/II's 1619 visit to Portugal, he returned to Madrid. He died there in 1624 (Domingues and Barker 1996).

Content: The first four chapters discuss architecture from a general point of view, counting naval architecture as one of the field's branches. The next three chapters discuss the types of wood to use in shipbuilding, how to choose which trees to use, and the best time of year to cut them. Portuguese cork oak is considered ideal for structural timbers (keel, keelson, sternpost, stem, transom, and frames) due to its resistance to rot, the easy of working it, and the readily availability of compass timbers (naturally curved timbers) suitable for certain parts. Stone pine is used for outer planking, due to its flexibility and resistance to rot and shipworms. Cluster pine, being lighter than stone pine, was to be used for the upper works of the ship. Red oak, according to the author, was only suitable for ships sailing to the northern latitudes, as it did not last well in tropical waters.

The remaining chapters are not numbered but describe the structural elements of the *nau* and how they are designed. The *nau* is designed on paper, using rules of thumb to set the proportions of different parts of the ship to each other, and circular arcs to define the shapes of the midship frame and the stem. Five frames fore and aft of the midship are pre-designed using a rising and narrowing scale derived from what Lavanha calls the *graminho de meia-lua*, which is equivalent to the Italian *mezzaluna*. See especially Vacas et al., 2010 for a complete description and illustration of the construction process described by Lavanha (Sánchez Pérez 1934; Barata 1965, 1996; de Viterbo 1988; Artur 1991; Coates 1994; Domingues 1994, 2000, 2004; Costa Valente 1996; Rahn-Phillips 2000; Vacas et al. 2010; Esteves 2011; Canas 2011).

***Ordenanzas para la fábrica de navíos de guerra y mercantes,* 1607.**

Author: Regulation issued by King Philip III of Spain and Portugal.

Country: Spain and Portugal.

Language: Spanish.

Location: Archivo General de Indias, Seville, Spain.

Notes: The *Ordenanzas* were published in 1607. A copy was filed in the Archivo General de Simancas and now resides in the Archivo General de Indias in Seville, as part of the set of documents called *Cartas y otros papeles tocantes a las pretensiones de los mareantes de Sevilla, causados desde el año 1600, 1602 a 1640*.

Also located: In 1792, Martín Fernández de Navarrete transcribed the archive above, including the 1607 *Ordenanzas*. This transcription is now housed at Madrid's Museum Naval (Fernández de Navarrete 1971).

Description: This is the first of three ordinances (1607, 1613, 1618) issued by King Felipe III of Spain and Filipe II of Portugal (1598–1621) in order to regulate and standardize shipbuilding on the Iberian Peninsula. Although Spain had a small standing navy, the *Armada del Mar Océano*, which was founded in 1580 to protect trade, naval ships and merchant ships had not yet specialized into distinct forms. The Crown obtained vessels for the *armadas* by leasing them from merchants. The *Ordenanzas* were intended to ensure that the country's merchant ships were suitable for use on both the *Carrera de India* and in the *armadas*. The ordinances were established to the recommendations of eleven of the best shipwrights and navigators of Spain (Juan de Uriarte, Martín de Zautua, Juan de Axpe, Domingo de Varienga, Martín de Sauto, Martín de Larraondo, and Juan de Veas) and of Portugal (Valentín Temudo and Captains Martiarto and Pedro de Sancturse). The *Ordenanzas* were extremely unpopular among shipbuilders and merchants, who felt the vessels built to the specifications sailed poorly and did not have enough room for either artillery or cargo. They were often ignored, despite fines being levied for not following them (Rodríguez Mendoza 2008a, b).

Content: The 1607 *Ordenanzas* are divided into four general sections. The first details the construction measurements for merchantmen and warships. It provides measurements for 13 sizes of ships: three *navios* of 10–12 *codos* of beam, two *galeoncetes* of 13–14 codos of beam, and eight *galeones* of 15–22 *codos* of beam. The following proportions were specified for each: the depth-in-hold (*puntal*); the overall length (*eslora*); the keel (*quilla*); the entries and runs (*raseles*); and the locations of the main deck, second deck (*puente*) if applicable, and the aft and fore castles. Many additional construction details, including the order of construction and the thickness of planking are also specified. The second section contains specifications for the hull structure and fortificaciones. The ordinance dictates the order of construction, the manner of reinforcing the stem and sternpost, the structure to support the deck, and how the decks and hull were to be planked. Little information about the frames of the ship is provided, except to dictate the measurement of the floor timber of the master frame and to explain that the number of frames depends on the runs and length of the vessel. The third section proposes a way to standardize the calculation of tonnage. Ships participating in the *Carrera de Indias* had to be of 567 toneladas or smaller, in order to be able to depart from the shallow ports of Seville, Spain and Veracruz, Mexico, and to ensure a timely loading and unloading of the cargo. The tonnage of each vessel was to be determined by a representative from the *Casa de la Contración*, according to the method presented in the ordinance. A specific formula is not provided. In addition, a mark was placed on the stem and sternpost, dictating the maximum allowable draft of the ship. Overlading was punished by forfeiting half the value of the cargo. The final section includes regulations on how the shipbuilders were to be paid (Rubio Serrano 1991; Rodríguez Mendoza 2008a, b).

***Arte para fabricar, fortificar, y aparejar naos de gverra, y mercante,* 1611.**
Author: Tomé Cano.
Country: Spain.
Language: Spanish.
Notes: Published.
Publications: (Cano 1611; Fernández Duro 1880b).

Description: Tomé Cano's *Arte para fabricar naos* is written in the form of a dialogue between three people: Gaspar, Leonardo, and Thomé, the latter of whom is a clear stand-in for the author who claims to have been sailing for 53 years and to have completed 29 round trips. It was published both as a naval treatise and as part of a broader debate in the Iberian Peninsula over the *Ordenanzas* first published in 1607.

Content: Cano objects to the ordinances, arguing that they are unprofitable for shipowners and the King should maintain a Royal Navy instead of leasing ships. Even though this book is not illustrated, it has a series of rules and measurements regarding the construction of ships for the Spanish Empire. Cano proposes that for a ship of beam 12 *codos, it should have a keel length of three times its beam (36 codos); for a ship with more than 12 codos and less than 15 codos, it should have a length of two times its beam (e.g., a ship of 14 codos should have a beam of 40 codos); and for a ship with more than 15 codos, it should have a length of 1.5 times its mean (e.g, a ship of 16 codos should have a beam of 43.5 codos). The differences between the ideal proportions for warships and merchant ships are also discussed (Cano,* 1611).

***Ordenanzas para la fábrica de navíos de guerra y mercantes y Ordenanzas para el arqueamiento de navíos,* 1613.**
Author: Regulation issued by King Philip III of Spain and Portugal.
Country: Spain and Portugal.
Language: Spanish.
Location 1: *Ordenanzas para la fábrica de navíos de guerra y mercantes*, Archivo General de Indias, Seville, Spain,

- Call No.: *Indiferente, no° 2595.*

Location 2: *Ordenanzas para el arqueamiento de navíos,* Archivo General de Simancas, Simancas, Spain,

- Call No.: *Guerra y Marina* collection, document 3146.

Publications: *Ordenanzas para la fábrica de navíos de guerra y mercantes* (Serrano Mangas 1992).

Description: Shipbuilders and merchants were deeply unsatisfied with the stipulations of the 1607 *Ordenanzas*. In 1610, the year the 1607 *Ordenanzas* were to take effect, a Royal decree was issued calling for a second assembly of experts to correct the mistakes of the first set. The council took two years to debate what changes should be made to the ordinances. They were signed by King Philip III on July 1, 1612. They were then sent to Luis Fajardo, the Duke of Medina Sidonia, and Admiral Diego Brochero. Both Sidonia and Fajardo felt that the length of the keel should be adjusted, with Fajardo arguing that every *codo* of beam, the keel should have 2 *codos* and Sidonia arguing that the length of the keel of all vessels should be reduced by 1 *codo*. Brochero declared the measurements ideal. No changes were made, and the revised ordinances were published on July 6, 1613. In addition, in 1612, a second meeting was called to discuss the calculation of tonnage and what measurement of the *codo* should be used. This council called on experts on mathematics, including Luis Arias de Loyola, Juan Cedillo Díaz, Antonio Moreno, and Don Alfonso Flores, as well as experts on navigation and shipbuilding, including Juan de Pedroso and Juan de Veas. A second ordinance, covering only the calculation of tonnage, was published on October 19, 1613. This ordinance was not overruled by the 1618 ordinance (Rodríguez Mendoza 2008a, b).

Content: The *Ordenanzas para la fábrica de navíos de guerra y mercantes* are made up of 106 articles. *Articles 1–15* detail the new measurements to be used to construct vessels. As in the 1607 ordinance, the dimensions of the keel, overall length, entries, and runs are provided, as are the locations and dimensions of the decks and the castles. In addition, the dimensions for the flat of the floor (*plan*), the spring of the stem post (*lanzamiento a proa*), the rake of the sternpost (*lanzamiento a popa*), the wing transom (*yugo*), the deadrise (*astilla muerta*), the outward tilt of the futtocks at midship and tail frames (*joba*), the sheer of the decks (*arrufadura de la cubierta*), and the wales (*arrufadura de las cintas*) are specified.

Fifteen different sizes of vessels are described, classified into *pataches* (8–10 codos of beam), *navíos* (11–13 codos of beam), and galleons (14–22 codos of beam). For *navíos* and galleons, the ordinances allowed some differences in construction depending on whether the ship was intended to serve as a merchantman or a warship. The *navio* of 11 *codos* beam had a second deck only if it was to serve as a merchant ship. Vessels of 12 *codos* or higher had their main deck ½ a *codo* higher if they were to serve as warships than if they were to serve as merchantmen, presumably to provide more headroom for the gunners. Depth-in-hold was to be half of the beam. The length of the keel was twice the beam plus an additional number of *codos*: for vessels of up to 18 *codos* in beam, 12 *codos* were added; for vessels of 19–21 *codos* beam, 11 *codos* were added; for vessels of 22 *codos* of beam, 10 *codos* were added.

Articles 16–20 detail how the hulls were to be assembled. How far from the stem and the sternposts the tail frames should be placed was specified. The width of the flat of the floor and the beam of the tail frames were set relative to those of the master frame.

Articles 21–72 detail the structural reinforcement of the hull. This included the size and placement of the wales and the thickness of the planking.

Articles 73–92 detail the rigging of vessels.

Articles 93–101 discuss the tools to be used in shipbuilding and how shipwrights were to be paid.

Articles 102–106 establish how the ordinances were to be applied. Shipbuilders were to get a copy of it from the superintendent of their district, and a fine of ¼ of the value of the cargo was to be levied if a vessel was found with dimensions outside those specified in the ordinances. In addition, vessels not fitting the regulations were not allowed to sail the *Carrera de Indias*. Ship owners were to be paid 9 *reales* per *tonelada* per month for vessels pressed into service in the *Armaa del Mar Océano*.

The *Ordenanzas para el arqueamiento de navíos* regulate the calculation of tonage. The calculation was based on the beam, depth-in-hold, the overall length, the length of the keel, and the flat of the master frame. The regulation provides three ways to calculate the tonnage: the first is used if the depth-in-hold is half the beam, the second if the depth-in-hold is more than or less than half the beam, and the third if the flat of the floor is half the beam (Rubio Serrano 1991; Rodríguez Mendoza 2008a, b).

***Livro de traças de carpintaria,* 1616.**

Author: Manoel Fernandes.

Country: Portugal.

Language: Portuguese.

Location: Biblioteca do Palácio Nacional da Ajuda, Lisbon, Portugal.

- Codex section.

Notes: 1 Vol. [140 fls.]

Publications: Facsimile (Fernandez 1989).

Description: The manuscript is a beautifully made presentation copy with a detailed index. The first sixty folios are text, all carefully lettered, and the remaining folios contain more than two hundred and fifty illustrations, painted in color using watercolors. It was not made for the use of practicing shipbuilders, but rather appears to have been created to describe or explain Portuguese shipbuilding to the Habsburg monarchy, which ruled both Spain and Portugal at the time of its creation (Rahn-Phillips 2000).

About the author: Little is known about the author. A handful of biographical details about people named Manuel/Manoel Fernandes have been identified, including a reference to a pilot, who qualified as a master for the route to Guinée and Brazil in 1602, and a 1615 marriage contract for a son of a Manuel Fernandes and Catarina Gonçalves to the daughter of one of the wealthiest families in a northern Portuguese town. However, the name was common, and Phillips (Rahn-Phillips 2000) finds neither of these details plausible for a shipbuilder. More likely to be relevant, she argues, is a warrant appointing a Manuel/Manoel Fernandes to succeed Valentim Themudo as master carpenter of the shipyard in Goa, although he never assumed the post due to a bureaucratic snag. An annual lifetime stipend of wheat (essentially a pension for a shipwright too old to work) was later granted to a Manuel/Manoel Fernandes in 1648, for his services as assistant master of ships' carpentry and master of galleys. The stipend was transferred to his wife in 1650, suggesting the date of Fernandes' death.

Content: The work is missing any introduction or dedication. This is highly unusual for the time, suggesting these pages may have been removed when the book was rebound in the late 1800s, possibly due to their association with the Spanish king (da Costa 1989; Rahn-Phillips 2000). While much of the work uses the Portuguese measurements *rumos* and *palmos de goa*, the table in folio 24 labels the beam and the length using the Spanish words *manga* and *esloria*, and the measurements listed use the *codo real* as its base of measurement. Several of the pages have similar phrasing or measurements as Gonçalo de Sousa's *Coriosidades,* suggesting that both authors were drawing from the same original source.

***Ordenanzas para la fábrica de navíos de guerra y mercantes,* 1618.**

Author: Regulation issued by King Philip III of Spain and Portugal.

Country: Spain and Portugal.

Language: Spanish.

Publications: (Rubio Serrano 1991).

Description: The 1613 *Ordenanzas*, like their 1607 predecessors, were unpopular. Shipwrights in Biscay and Guipúzcoa demanded the freedom to design ships the way they wanted to, arguing that building only vessels that could also serve as warships was unfair to merchants. In Seville, Admiral Aparicio Arteaga and shipbuilders Diego Ramírez and Álvaro de Utera met to create a report detailing the problems that the ships built to the specifications had. They were especially critical of the length of beam, arguing the ships should be wider.

In 1618, a new council met to further revise the ordinances. The revision was published on June 16, 1618, and this version was accepted as the best compromise shipbuilders and merchants were likely to get. This revision did not overturn the 1613 ordinance on the calculation of tonnage, but only the 1613 ordinance on shipbuilding. This revision of the ordinances remained in force unchanged until modifications were introduced in 1666 and 1679 (Rodríguez Mendoza 2008a, b).

Content: The *Ordenanzas* of 1618 followed a similar pattern to the 1613 *Ordenanzas*, with 106 articles.

Articles 1–14 detailed the measurements of the ships. There was no distinction between different types of ships; all ships were called *navíos*. Fourteen sizes were described, from 9 to 22 *codos* of beam. The 1618 version reversed the distinctions between merchantmen and warships established in 1613, so that all vessels of a given beam were to be built to the same dimensions. The dimensions of the outer sternpost (*contracodaste*), the location of the bitt (*bita*), and the shape of the fashion piece were added to the previously specified dimensions. The lengths of the keels were reduced by 2 *codos*. The depth-in-hold was to be measured at the maximum breadth, rather than at the deck, and was to have a ratio beam to depth-in-hold of 1:0.45. The main deck was placed ½ a *codo* above the maximum beam for all vessels, rather than just ships intended for use as warships.

Articles 15–71 detailed the structural strengthening of the ships. No changes were made to these regulations.

Articles 72–91 detailed the rigging of the vessels.

Articles 92–101 specified the tools to be used by the shipwrights and how the shipwrights were to be paid.

Articles 102–106 established how the ordinances were to be applied (Rubio Serrano 1991; Rodríguez Mendoza 2008a).

***Discursos sobre la navegación de las naos de la India de Portugal*, 1622.**

Author: João Pereira Corte-Real.

Country: Portugal.

Language: Spanish.
Location: : Biblioteca Nacional de Portugal (BNP), Lisbon.

- Call No.: *Impressos Reservados, RES. 1196//3 P. Microfilme collection, F.7619.*

Notes: First edition copies are held by the National Library at Lisbon—which holds a copy of both the printed version in Spanish and the manuscript version in Portuguese—and in Charles Boxer's private collection—a copy that includes marginal annotations and a final autograph note signed by the author, as well as two manuscript drafts on the same topic: one by Gaspar Roiz, a *Carreira da India* pilot, concerning the sailing of a Portuguese fleet to India 1624–1625, where Corte-Real served as second-in-command. Boxer mentions the existence of one other original copy (Boxer 1940).

Publications: Originally published in 1622 (Pereira Corte-Real 1622). Transcriptions of both the Spanish and Portuguese versions were published in the Boletim da Sociedade de Geografia de Lisboa, 17a Serie, No. 1 (Barcelos 1898).

Description: João Pereira Corte-Real was a Portuguese admiral, but *Discursos* was printed in Spanish in Madrid, in order to provide the combined Spanish and Portuguese crown with recommendations for the regulations of the Portuguese *Carreira da India*. It was written at the request of Diego Brochero, a member of the Council of War in Madrid who was "arguably the driving force behind Spanish naval reform in the early seventeenth century" (Rahn-Phillips, 2000, 16). Much of the material in it was drawn from earlier proposals that Pereira Corte-Real had submitted to the King, including a proposal in 1619 to pay sailors on the *Carreira* wages instead of allowing them to bring back a quantity of trade goods (the money for the wages was to come from establishing a monopoly on the importation of cinnamon). The proposal was not adopted. *Discursos* was printed and circulated for a small audience of high officials, such as members of the Council of War. Manuscript copies in Portuguese were also circulated.

About the author: João Pereira Corte-Real was born around 1580. He was well educated and likely began his service in the *Carreira da India* in 1603. By 1619, when he was asked to write the proposal, he was an experienced naval commander who had made at least four voyages to India and back again. He served as the Admiral of the Fleet and Colonel of Marines for two years, 1622–1624, during the temporary disgrace of naval commander-in-chief, General Dom Antonio de Ataide, and his second-in-command, Admiral Dom Francisco d'Almeida, due to Algerine Pirates burning the *Nossa Senhora da Conceição* in 1621 (Rahn-Phillips 2000).

Content: The work weighs in on a debate in the Portuguese maritime community about the relative benefits of large, four-decker carracks, often called *naus*, which were preferred by the Portuguese for the *Carreira da India*, versus smaller, three-decker galleons, which were preferred by the Spanish because they could be used for both trade and warfare. In 1619, Pereira Corte-Real had presented to King Philip III/II an opinion that the *naus* were superior to the galleons: "The ships [for the *Carreira*] ought to be of four decks and never three, because [the former] carry more people and haul more cargo and in warfare they lord it over the castles of other ship and are much more defensible" (Rahn-Phillips 2000). However, his *Discursos*, published in 1622, opens with the hope that it "could be a means by which Your Majesty will order a remedy for the many damages that have been caused in your royal service, to the state, royal finance, and warfare by these errors, which all consist of two things: One, in the form of the *naus* and the immensity of their size. And the other, in the mode of loading them" (Rahn-Phillips 2000). In 1622, the king ordered that Portuguese ships should have three decks instead of four. The decree had to be issued again the following year, suggesting that Portuguese shipbuilders and merchants were resistant to the regulations. The prohibition of four deck ships was never fully achieved, and no regulations stipulating exact dimensions were issued for Portuguese ship construction (Barcelos 1898; Boxer 1940; Hernani Amaral 1992; Rahn-Phillips 2000).

***Coriosidades de Gonçalo de Sousa,* c. 1630.**

Author: Gonçalo de Sousa.

Country: Portugal.

Language: Portuguese.

Location: Biblioteca Geral da Universidade de Coimbra, Portugal

- Call No.: Ms. 3074.

Notes: Unpublished.

Publications: Partial transcription in (Domingues 2004).

Description: The date of the manuscript has been determined based on two points: it copies some information from the 1598 *Traça de uma nau da India* by Gonçalo Rodrigues, and it includes a handwritten report regarding the outfitting of a fleet to India, written by Vasco Fernandes César, *Provedor dos Armazens e Armadas*, in 1627. The manuscript held by the University of Coimbra may itself be a copy of an original that is now lost, based on the errors it contains and the references it makes to images that are not included. The similarity of the wording and overall structure suggests that both *Coriosidades* and Manoel Fernandes' *Livro de traças de carpenteria* were copied from the same source (Hernani Amaral 1992).

About the author: Not much is known about the author, other than that he was the captain of the only surviving ship of the 1627 disaster of the coast of France, the galleon *S. Tiago* (de Melo 1931), where both India *naus São Bartolomeu* and *Santa Helena*—from the fleet of 1625—had to be beached due to a tremendous storm. Gonçalo de Sousa managed to sail the galleon *S. Tiago* to the bay of Getaria, in the Basque Country, and survive the storm. Hernani Amaral (Hernani Amaral 1992) argues that the errors made in the text suggest that it was copied by someone who did not know much about shipbuilding, although it is not clear whether the manuscript should be attributed to Gonçalo de Sousa or to a later copier.

Content: The *Coriosidades* are a precious compilation of shipbuilding texts:

Folio 1: Empty.
Folio 2: Introduction by Gonçalo de Sousa.
Folio 3: Cover.

Folio 4: Poem dedicated to the king: "Such curiosities can only be found in you…".
Folios 5 to 13: Regra geral para navios de alto bordo de 60 ate 300 toneladas.
Folio 8: Maneira como tirarás a caverna mestra.
Folio 13: Ao navio de 150 toneladas marchante.
Folio 13: Navio de 300 toneladas.
Folio 14: Caravela de 50 moios.
Folios 14 to 26: Conta das medidas de uma nau da Índia.
Folio 15: Conta da caverna mestra e largura dela às cobertas.
Folio 16: Conta que terás no lançar da primeira coberta e medidas das escotilhas, cordas, pés de carneiro.
Folio 17: Conta como tirarás uma caverna mestra.
Folio 17: Lembranças dos carreiros de curvas da primeira coberta da ordem delas assim de revés como de convés.
Folio 18: Conta de como tirarás a roda de proa e de como a rodarás.
Folio 19: Conta que será no latar e [?] da segunda coberta que tem a dos agasalhos e do assentar da estrinca [e] fazer do sisbordo.
Folio 20: Conta de como tirarás o rodaste de uma nau, ordem para o lançamento deste.
Folio 21: Conta com o encurvar da terceira coberta que é a da bita com assentá-la ao cabrestante grande e agasalhos e assim curvas de revés.
Folio 21: Para pôr a caverna mestra.
Folio 22: Como hás-de empresar as cavernas.
Folio 22: Conta com o latar da coberta da penta com o encurvar do convés, com o fazer do castelo de proa e gurita ate o acabar.
Folio 23: Maneira de como assentarás as alturas da cinta à popa, da proa e a altura da coberta para a fabricares.
Folio 24: Conta que se há de (fazer digo) ter no fazer da tolda, como [?] do convés e revés ate se acabar.
Folio 25: Maneira como tirarás as firmas da aposturagem redonda e pés de castelo.
Folio 26: Conta como tirarás a forma para a primeira abóbada que cai sobre o leme das cambotas da segunda abóbada.
Folio 26: Conta de quanto cairá o primeiro virote ao pé do mastro.
Folios 26 to 31: Conta que terás no fazer de uma galé de 24 bancos sotil.
Folio 27: Que. terás para tirar a forma da [?] e braço e conta do graminho e cavernas de conto.
Folio 28: Conta que seguirás nas armaduras.
Folio 29: Conta que terás no cintar desta galé.
Folio 29: Conta que terás com os terços da caverna mestra.
Folio 30: Conta que terás com o alcaixal.
Folio 30: Conta boa dos de fixo entre a faixa e a faixa de tapar.
Folio 31: Conta que terás para a altura da cinta e coberta a que chamam contanal.
Folio 31: Conta que terás no assentar dos buncacetes.
Folio 33: Regimento da nau da Índia de Gonçalo Rodrigues de 17 rumos.
Folio 36: Quadro com medias de Quilha, Eslora, Manga e Pontal para vários tamanhos de navios.

Folio 36: Regimento do dito galeão de 14 rumos como tenho dito e tinha mais meio rumo.
Folio 44: Regimento para bateis, barcos, fragatas, bergantins e esquifes.
Folio 46: Regimento do batel de 12 goas.
Folio 46: Regimento para uma fragata até 10 goas.
Folio 49: Despesas para fazer 12 galeões de 550 toneladas cada um (3 de Agosto de 1627).
Folio 56: Lista de artilharia.
Folio 60: Navios extraordinários que no estado da Índia se costumam armar, de que cá não usamos.
Folio 62: Aparelhos de um galeão.
Folio 66: A ordem antiga de guerra que se tinha em companhias de infantaria é a seguinte.
Folio 76: Regimento dado pelo general Dom António de Ataíde aos capitães da armada.
Folio 96: Carta régia a Pêro Correa de Lacerda.
Folio 115: Carta régia a Pêro Correa de Lacerda (Regimento 78).
Folio 126: Carta régia a Pêro Correa de Lacerda.
Folio 144: Carta régia a Pêro Correa de Lacerda.
Folio 152: Carta de D. António de Oquendo.
Folio 176: Instrucción y orden que vos nombrado, habéis de guardar en el uso y ejercicio de vuestro oficio por lo que toca al ministerio de la artillería.
Folio 180: Regimento de capitães mor das naus da Índia no ano de 1629.
Folio 200: Regimento dos capitães mores.
Folio 212: Regimento que deu Dom Manuel de Meneses (1626).
Folio 222: Resolucao que sua majestade mandou tomar no ano de 1621 na arma de Portugal.
Folio 224: Relacao de todos os generais e entretenidos.
Folio 230: Caballeros que vinham na armada de [?]
Folios 232 to 238: Soldos das companhias da Flandres de Infantaria.

(Hernani Amaral 1992; Domingues 2004)
***Diálogo entre un vizcayno y un montañés sobre la fábrica de navíos,* c. 1632.**
Author: Anonymous, possibly Pedro Lopez de Soto.
Country: Portugal.
Language: Portuguese.
Location: Library of the University of Salamanca, Salamanca, Spain.

- Call No.: Ms. 2593.

Publications: (Vicente Maroto 1998).

Description: The manuscript *Diálogo entre un Byzcaino y un montañes sobre la fábrica de navíos* is perhaps the work of Pedro López de Soto, according to Ma Isabel Vicente Maroto (Vicente Maroto 1998). It was written around 1631 or 1632 and is intended to criticize the ordinances of 1618. This work is in disagreement with Escalante de Mendoza when he said that the Biscayan and Portuguese construction was the most superior to all. The author of this dialogue "adduces as an example and justification of his proposals what was done in the Flanders Navy, the famous Dunkerque frigates, whose ships are built and manned following the Flemish systems, which the author recognizes as superior to those employed in Spain, superiority that he also attributes to the Dutch enemy." He proposed "flat" ships, suppressing fortresses and castles as well as improving artillery. The author proposes the construction of a 500-ton galleon so that the prototype can be verified.

***Arqueação da nau Nossa Senhora da Oliveira*, 1634.**

Authors: Bartolome Alvez and Manuel Fernández.

Country: Portugal.

Language: Spanish.

Location: Biblioteca da Ajuda, Portugal.

Call No.: Ms. 51-VI-28.

Description: This document describes the calculation of the tonnage of nau *Nossa Senhora da Oliveira*, a four-decked ship with a keel of 30 m and a beam of 15.65 m. The tonnage is calculated with arcs represented the maximum diameter of a ton, and gauges representing a ton's height. The resulting figures were 484 tons in the hold—which had a vertical clearance of 3.72 m—and 525 tons in the lower deck— which had a clearance of 2.05 m. From the total 1009 tons the officers deducted 35 tons: 19 1/3 tons because of the space lost due to 19 hanging knees, 8 1/3 tons from 25 standing knees, and 8 tons from the space occupied by the masts, pumps, and pump sump. Following this calculation is the list of the main dimensions of *Santa Catarina*.

About the authors: There are documents in Arquivo Historico Ultramarino (Reino, Cx. 6, 1634) pertaining to the career of Bartolomeu Alvarez, a third-generation master shipwright at the royal shipyards at Lisbon, the Ribeira da Naus, who built the above-mentioned ships. Very few documents, however, mention a shipwright named Manoel Fernandez. Could this be the author of *Livro de Traças de Carpintaria*?

***Advertências de navegantes*, c. 1640.**

Date: 1640–41.

Author: Marcos Cerveira de Aguilar.

Country: Portugal.

Language: Portuguese.

Location: Biblioteca Nacional de Lisboa, Portugal.

Call No.: COD. 13,390.

Notes: Unpublished.

Description: It is a bound manuscript with detailed illustrations, written with a clean and clear calligraphy that can be easily read. Hernani Amaral (Hernani Amaral 1992) mentions several instances of striking similarities with Tomé Cano's text.

Content: According to the author: "a practice (by conversation) between a captain, with little experience at sea, and his militia; and a soldier with a lot of experience at sea about the duties of captains of sea and war (*capitães de mar e guerra*).

And some of the officers in it and their positions. And it treats briefly of the artillery with which a galleon must be armed and how it will be fixed to fight. How to build a warship in the shipyard, with some measures to get it well proportioned, and some names of parts and construction team members; with the measures of the masts, yards, topmasts and sails in perfection. How to rig a ship to sail and all its standing rigging, and how it works? How to make a compass and the old ones were? How to take the Sun with the astrolabe, how to make its calculations and chart positions with ease? Declaration of the bars and seaports on our coast of Portugal, from Cabo de São Vicente to Finisterra, and from the same Cabo de São Vicente to Cádiz, Gibraltar, and entrance from the strait to Cartagena and the East (Levante). A brief practice and a summary of tables with square roots."

About the author: According to Portugal National Library catalogue, Marcos Cerveira de Aguilar Marcos Cerveira de Aguilar was *capitão de ordenança* in Setúbal, and the author of another surviving work, such as *Diálogos das armadas e naus de guerra destes reinos de Portugal e senhorios*, addressed to Count D. Diogo da Silva (da Costa 1940, 1960).

4 Conclusion

Considering the issue of Iberian ship design from both the macro and the micro points of view, and taking into consideration all the available knowledge in historical documents, iconography, and the archeological record, a consistent image of Iberian vessels emerges, making a compelling argument for the existence of an Iberian Atlantic shipbuilding tradition that was legislated and regulated during the period of the dual crown. Iberian ships are diverse, both in the design and construction, but the available archeological evidence suggests that the construction of ships for the Atlantic routes, and later Indian and Pacific Oceans routes, brought about something like an evolutionary convergence. If it is possible that the ships built along the Mediterranean coasts of Spain were closer to the ships built by the Sicilians and along the west coast of the Italian Peninsula—we really do not have much archeological evidence to suggest otherwise—it seems that the ships of the Atlantic coasts of the Iberian Peninsula may have shared conception and construction traits with each other. Until 1580 there is, however, no clear image of the types of vessels built from the Basque Country to the Strait of Gibraltar and therefore it is not possible to establish typologies nor to map influences, exchanges, or diffusion of design or construction traits. Iberian ships may have been similar in a loose combination of conception and construction traits. Developed in the nexus of the North European and Mediterranean shipbuilding traditions, Iberian ships may constitute a unique cultural tradition in shipbuilding. It is characterized by the rounded midship frame, with a flat in the central part; the presence of dovetail scarfs in the connections between floor timbers and first futtocks; the *as-dos-tres* proportions, making the keel length around twice the ship's beam and the length overall around three times the beam; the stems shaped along a circular arc, tangent to the keel; the use of reinforcements on the connections between the keel and the stem and sternpost; and the use of treenails and iron nails—or only iron nails, as we move west and then south, along the Portuguese coast. The basic measurement units are different, even if both *rumos* (1.54 m) and *codos* (57.5 cm) appear in Fernandez's tables of dimensions. Eric Rieth (Rieth 1988) mentions something like a familiar look, "un air de famille" that is common to most Iberian ships of this period (Hernani Amaral 1992; Rahn-Phillips 2000; Alves 2001).

We can only hope that at least some Iberian shipwrecks found in the future will be archeologically studied, adding to the sample of collected data and possibly solving some of the ongoing questions. Questions about the tangent of stems to keels, consistent proportional arcs in the stem, the rake of sternposts, low length to beam ratios, and fully integrated fore and stern castles are just a few of the issues awaiting answers to from the vault of archeology. But there are many other issued that beg further research: the question of the *dentes* or little protrusions in the frames drawn in Lavanha and Fernandez' treatises, and so far only found on the Oranjemund shipwreck, thought to be the remains of *Bom Jesus*, an India nau lost in 1533 in its outbound trip. Other important architectural signatures must be further investigated. The arrangement of the bottom stringers, ceiling, pump sumps, and mast-step buttresses, the number and arrangement of reinforcements, such as standing and hanging knees, riding timbers, or the illusive *entremichas* mentioned in the documents with vague definitions, all need to be checked and criticized against archeological data. Only further scientific research of archeological remains of ships across many nationalities from the same cultural horizon will provide further evidence as to how particular or homogeneous the Iberian shipbuilding tradition was during the Age of Exploration.

For all these reasons, the question of the protection of the Iberian shipwrecks is a pressing one. As we write these lines, news of untouched shipwrecks being looted are circulating about shipwrecks in Panama, Uruguay, Brazil, and international waters near Cyprus, and about a standing attempt from a treasure hunting group to destroy the Colombian shipwreck *San José*, untouched in deep water. Antique dealers seem to have diversified their activity and connected into a network with relations to organized crime and terrorist organizations (Watson and Todeschini 2007; Alderman 2012). Portuguese and Spanish shipwrecks have been systematically destroyed by treasure hunters worldwide, sometimes with the cooperation of professional archeologists (Bound 2004; Castro and Fitzgerald 2006). The authors hope that this book contributes to a better understanding of the importance of these ships in the histories of technologies and ideas, and that governments continue expanding the protection of the global maritime culture heritage against looting and treasure hunting.

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Chapter 12
Maritime Vocabulary in Texts: Friar Joseph de Ledezma (1701)

Roberto Junco Sánchez

Abstract This chapter deals with a maritime vocabulary from the written text of the friar Joseph de Ledezma, who composed a manuscript about his travels from America to Europe and back, at the end of the seventeenth century. Besides his voyages, he presents a vocabulary with words he deemed important to describe the ship, the manoeuvres on board, the positions and ranks as well as other curious observations. This maritime vocabulary, one of the few known to the modern researcher, is particularly interesting as it is not the work of a sailor, but a priest. His selection of the words is thus peculiar and important to describe what it was to be onboard a *Carrera de Indias* ship in the year 1700.

1 Introduction

One of the first problems encountered by anyone interested in studies about Spanish navigation between the sixteenth and nineteenth centuries is undoubtedly that of having to acquire terms which, at first glance, may seem odd and complicated (some of which are still in use today, albeit with a different meaning). However, this stumbling block—as any learning curve in the field of language—is but a temporary problem insofar as we start to incorporate to our language, through repeated use, these formerly common words and concepts that invoke the universe of ancient seafarers. For this purpose, a brief introduction to Spanish maritime vocabularies is

The original version of this chapter was revised. The correction to this chapter is available at https://doi.org/10.1007/978-3-030-86460-6_14

R. Junco Sánchez (✉)
Instituto Nacional de Antropología e Historia (INAH), Mexico City, Mexico

A. Crespo Solana et al. (eds.), *Heritage and the Sea*,
https://doi.org/10.1007/978-3-030-86460-6_12

presented, along with commentaries on the manuscript of Joseph de Ledesma. Furthermore, his maritime vocabulary is presented.[1]

2 Nautical Jargon

The importance of navigation throughout modern world history is well known: the Age of Discoveries, overseas communications, and commercial trade. The ships that made this possible were, without question, examples of sophisticated and complex technology, if one considers the great number of operations they engaged in and the individuals involved in such endeavour. Therefore, the body of words that emerged as a result, to name each part that composed a ship, as well as its operation, is in itself a world that researchers must embrace, to accurately understand the phenomenon at hand. The introduction to the *Maritime Vocabulary* of 1722 reads: "It is, discreet reader, to my knowledge, the Ship, the greatest vessel to ever be thought up by man through his abilities and hard work; and as such, machine of all machines, it seems by no means disproportionate to have devised a vocabulary to explain the terms or name the elements that comprise such ships [...]" (Anonymous 2000).

This alive and thus ever-changing universe has adopted and discarded many a word throughout the centuries, especially when considering the introduction of steam and later internal combustion engines. Therefore, the maritime jargon has suffered many changes, and thus, in broad strokes, in the sixteenth and seventeenth century there is mention of *arbol* (mast), whereas by the beginning of the nineteenth century the word *palo* was used to refer to the same nautical element. Regarding the definition of *palo*, O'Scanlan says as follows: "Formerly it was called *mastil* and also *arbol*" (O'Scanlan 1831). This is one of the reasons why Ledesma's document is so interesting, for it freezes in time the maritime world of the late seventeenth century *Carrera de Indias*.

2.1 Maritime Vocabularies

Few are the works that compile terms preceding Ledesma's Maritime vocabulary. As far as printed works, the first of its kind to come to light from the pen of Diego García de Palacio was printed in Mexico City in 1587. His work, *Instrucción Náutica*, includes in book IV, a vocabulary of 506 words. I believe that one of the reasons why García de Palacio put forward this extraordinary universal lexicographical contribution is due to the influence of printed vocabularies in indigenous languages, abundant

[1] Ledezma, Joseph de (1701), *Itinerario Historial Viaje que hizo de la America Septentrional a la Europa M. R. P. Fr. Joseph de Ledesma, hijo de la Santa Provincia de los Santos Apóstoles San Pedro y San Pablo de Michoacán en la Nueva España Lector de Sagrada Teología y Proministro para el próximo capítulo general de su religión que se celebra en la Santa ciudad de Roma el año de 1700*. Library of Congress, Washington D.C., Manuscript Division, Shelf No. 23, 527.

in New Spain, and that resulted greatly effective in evangelizing and communicating with the native peoples. Just to mention a few: those of Friar Alonso de Molina in Nahuatl in 1555, printed by Juan Pablos, and in 1571 by Antonio de Espinosa, that of Friar Maturino Gilberti in 1559 in the Purepecha language by Juan Pablos, that of Friar Juan Bautista de Lagunas in 1574, in the aforementioned language, by Pedro Balli, and that of Friar Juan de Córdova in the Zapotec language in 1578 by Pedro Ocharte, the same printer responsible for *Instrucción Náutica*.

Following García de Palacio's great work, Tomé Cano's work was published in 1606: *Arte para fabricar naos*, which includes a "declaration of words" comprising 77 terms. While the amount of words is not as important as in the precedent complication, 27 of them had not yet been mentioned, according to Nieto Jiménez's thorough analysis (Nieto Jiménez 2002).

As regards the famous dictionary *Tesoro de la Lengua* by Sebastián de Covarrubias written in 1611, it contains some maritime definitions, which, as pointed out by historian Trejo in her analysis of García de Palacio's work, are based on *Instrucción Náutica* (Trejo Rivera 2009). Lastly, I shall mention a phantom edition: the *Vocabulario Marítimo* of 1696—that comprises 216 terms—of which no known copies survived. However, Martín Fernández de Navarrete noted that Sebastián Fernández de Gamboa's 1696 manuscript would correspond to this edition, which was reprinted in 1722 and published anonymously, with a 245-word enhancement (Nieto Jiménez 2002).

Until this point, I have only mentioned books printed before Ledesma's manuscript, because although there are a few known manuscripts, it is unlikely that the author would have been able to consult them. Amongst these manuscripts are: Alonso de Chávez, *Espejo de Navegantes* (written between 1520 and 1538); Juan de Moya, *El arte de marear* (1564); Andrés de Poza, *Hidrografía la más curiosa que hasta aquí ha salido a luz…* (1585); the anonymous *Bocavulario navaresco* (circa 1600); Eugenio de Salazar: *Navegación del alma…* (Circa 1600) (Martínez 1999, 109); the anonymous *Derrotero del mar Mediterráneo* (1614); Manuel de Ayala, *Diccionario marítimo o Promptuario náutico* (1673); and finally Pedro Fernández de Navarrete's *Breve diccionario de términos de marina* (1675) (Nieto Jiménez 2002). This is everything I have been able to compile up to now, printed or handwritten, prior to Ledesma's vocabulary.

Throughout the eighteenth century, lexicographical compilations appeared, such as the one written by Antonio de Ulloa in his work *Conversaciones de Ulloa con sus tres hijos al servicio de la Marina* (de Ulloa 1795), until the appearance, in 1831, of Timoteo O'Scanlan's famous *Diccionario Marítimo Español*, which remained, for many years, the most ambitious compendium of maritime terms. However, this dictionary is not the product of a lexicographical accumulation of other terms, but rather of emulating the European—encyclopaedic—works, such as the four *Marine* volumes of the famous 1783 *Encyclopédie Méthodique, Marine, de Panckoucke* (Panckoucke 1783).

2.2 The Manuscript

The manuscript that encompasses all the terms presented in this work is safeguarded at the Library of Congress in Washington D.C. and is entitled: *Itinerario Historial Viaje que hizo de la America Septentrional a la Europa M. R. P. Fr. Joseph de*

Ledesma, hijo de la Santa Provincia de los Santos Apóstoles San Pedro y San Pablo de Michoacán en la Nueva España Lector de Sagrada Teología y Proministro para el próximo capítulo general de su religión que se celebra en la Santa ciudad de Roma el año de 1700. Itinerary of the Journey from Northern America to Europe, undertaken by M.R.P. Fr. Joseph de Ledesma, son of the Sacred Province of the Holy Apostles Saint Peter and Saint Paul of Michoacan in the New Spain, Lector of Sacred Theology and Prominister for the next general chapter of his religion which will take place in the Holy city of Rome on the year 1700.[2] I have been able to verify the existence of another copy of this manuscript in Mexico, as part of the collection of an eminent bibliographer who was kind enough to allow me to consult it. Both bear the same information, although the private copy contains the figure of a ship, whereas the Library of Congress copy contains a list of 31 parts of the ship, and the space in the page on which the figure would have been drawn is blank. This detail, as well as the 1749 date—that could well be the date in which the copy was manufactured—proves that the copy presented here, that of the Library of Congress, is a subsequent one.

It is interesting to note that the manuscript, bound in parchment, contains the *ex libris* of an eminent nineteenth-century Mexican bibliographer, Don Vicente Andrade. Furthermore, it contains the *ex libris* of Maximilian of Habsburg Emperor of Mexico, of whom it is well known he acquired Andrade's library, and after whose fall, Father Fisher sold the said collection throughout Europe and the United States. A "Jose de la Rosa" handwritten *ex libris* can also be observed, as well as another one with the stamp "Antonio de la Rosa". Generally speaking, it is in good condition; however, the top corner of the text presents some damage due to moisture, leaving the reader in suspense in certain passages.

About the author, Beristáin y Souza mentions in his famous *Biblioteca Hispano-Americana Septentrional* that he belonged to the Franciscan Order and as a custodian, he travelled to Rome, where he had the opportunity to listen to the city's most emblematic orators. Upon his return to New Spain, he retired at the *Colegio de Celaya* and lost his eyesight. However, he was able to identify every single volume of his copious library, accounting for its content. He was the author of the book *Silvos del Pastor Divino*, printed in Mexico by Juan Ribera in 1682 (Beristain de Souza 1816). In more recent years, Gómez Canedo carried out a study on Ledesma and on the work in question, entitled *Dos viajeros mexicanos en Europa a fines del siglo XVII* (Gómez Canedo 1981). Gómez Canedo unveiled details concerning the life of this priest born in Chamacuero, Michoacan, such as the fact that he was a philosophy professor at the *Colegio de Celaya*, amongst other interesting information. As far as the vocabulary is concerned, he states: "Amongst his observations as a seaman, which are few, he puts forward an interesting nautical vocabulary". (Gómez Canedo 1981).

The manuscript in question talks about Ledesma's 1698 travels, from Mexico City to Rome, for the General Chapter of the Franciscan Order. It describes his

[2] Ledesma. Library of Congress (passim).

outward journey, his passing through different Spanish, French, and Italian cities, his curious observations—for instance, that of the Vatican's library in Rome or his attendance at the Naples opera—right until his return to Veracruz on March 23rd, 1701. This is when he began to write his *Vocabulario Marítimo* with a description of the routes, illustrated with the figure of the compass rose. He then lists the terms that describe the (absent) figure of the ship, of which he says: "the explanation behind these terms could be found in the vocabulary according to the first letter". Then comes the vocabulary and then "how things and events are transmitted from one ship to another", and "the duties and officers of the ship". He concludes with some advice "to those who set sail for the first time", for instance, guidance concerning the currency exchange in Catalonia, France, Genoa, Milan, Bologna, and Naples. The manuscript comes to an end on sheet 181 r.

It is worth mentioning that the vocabulary in question is neither the most extensive nor the shortest: his body of terms includes 133 words, and as a whole, it is of great interest for it describes a ship that was part of the *Carrera de Indias*. To understand the reasoning behind the vocabulary, we must place ourselves on the deck of a ship, on the verge of weighing anchor in the harbour, with the cool wind blowing. Preparations commence. Operations follow their course. Sailors moving to and from, under the orders of the petty officer. We are confined within the great floating machine; all that separates us from certain death is a few centimetres of wood, the captain's better judgement, and the divine Providence. After several days on the high seas—which are nothing more than a blue desert—everything becomes tedious and monotonous, while tension starts to rise amongst the crew. So, in the words of José Luis Martínez: "…it could be entertaining to register the sailors' peculiar language that, over the years, constituted a jargon for which special vocabularies have been created to decipher it" (Martínez 1999). Eugenio de Salazar says: "A great thing it is that I learned so much of that language in forty days…" (Martínez 1999), which leads us to speculate that curious spirits, it would seem, made good use of their time by observing and learning about the ship's different components and manoeuvres. Thus, perhaps the intention is to accompany the account of their journey with a vocabulary, because in doing so, the storytelling becomes ever more dramatic, especially when the language used to describe each experience to the reader is perfectly comprehensible. However, Ledesma himself specifies his reasons in the opening of his vocabulary: "Propriety in speech, concerning the matters recounted, are not useful only for (mainly) scholars to comprehend correctly. Many a time it is also necessary for political conversations and in the pulpit to speak of nautical matters, describe storms or draw ships, or relate journeys, to those not versed on ship parts or on the meaning of the terms that are mentioned. To one and the other this vocabulary will be of profit; of the precedent figure, they will know of the parts of a ship and its situations, and then I shall offer the nautical terms and meanings: but with the warning that many sailors often employ different terms, so, I shall offer the ones most often used".

It is interesting to note that the author mentions "pulpits" amongst his motivations and certain sermons are known to have a vast amount of maritime terms, which seems to point to the fact that they might be more common than previously thought, like, for example, the famous *Oración Eucaristica* by the aforementioned Beristain y Souza (Medina 1991). Conversely, State responsibilities would include this jargon in matters relating to accidents or to relate the vicissitudes of the journeys on the King's ships. In 1795, the wise sailor Antonio de Ulloa, in his above-mentioned work *Conversaciones*, that includes a substantial dictionary as a complement to his advice, specifies the following: "To ease the comprehension of nautical terms for those who, out of curiosity, indulge on brief moments of amusement with our conversations and entertainments, and do not have that comprehension, I shall offer a vocabulary that refers to those terms so that they will understand their meaning, for our maritime speech is different in many of its expressions to the language spoken on land" (de Ulloa 1795). For his part, another great sage Martín Fernández de Navarrete (not Pedro Fernández de Navarrete, mentioned earlier in the text), in his essay that was to become the prologue to O'scanlan's *Diccionario Marítimo Español*, said soon after: "But if this investigation might be useful for nautical history, or of some curiosity for old scholars, the knowledge of the appropriate words is not only indispensable for the teacher, it is also so for the orator, the poet, and anyone wishing to read with intelligence and write correctly and accurately" (Fernández de Navarrete n.d.). The spirit is the same: to understand and speak the same language. One might wonder whether there is a language barrier that may alienate those initiated in seamanship because, in their own words, they seek to explain themselves through the vocabulary of others. As for the content of the vocabulary, if we divide the whole of Ledesma's expressions by themes, we can observe that the author devotes over a third of the entire collection to words relating to the masts and the rigging of the ship. In my opinion, this has to do with the fact that the author would spend most of the day on the deck watching the sailors' manoeuvres. Another third of the vocabulary is dedicated to the architecture of the ship, but several basic terms are not included, for example, *Stem, Stern post, Strake, Tonnage*, amongst others. The remaining words are divided between tools/machines and life aboard/the crew. As an example of tools, we may mention *Lampaso:* a scrubber made out of strands tied to a stick to mop the ship with; or Lanita: a lamp fixed to the binnacle for the helmsman to see the needle at night. Moreover, the vocabulary is rich in words that refer to everyday life, for instance, *Rebenquez:* pieces of rope, well tarred, used to punish the cabin boys and pages who do not fulfil their ministry, or for example, the term *Zalomar:* a sea shanty hummed by sailors as they complete their chores. These words also bring us closer to the everyday life onboard the ship, and we can picture a cabin boy on the galleon's deck doing penance with the *rebenquez* while sailors pull on a rope while chanting a *zaloma* to which others respond. In this manner, by consulting this vocabulary we also tour through a ship engaged in the *Carrera de las Indias* and closer to its crew. Amongst the phrases not included in the aforementioned maritime vocabularies, as far as practices on board are concerned, there is this very revealing definition of *Oratorio:* is the chapel where mass is said and it is well sheltered to administer sacraments. In some ships, it is placed in the stern cabin, under the quarterdeck. In some others, it is joined to the cabin itself in such a way that mass can be attended from within, but others just do not have it so a table is placed on the quarterdeck when mass is to be celebrated. There is also the term *Rancho*, which Ledesma describes at length and that reveals a lot about how the ship's crew is organized: "It is a company of seven or more men who each give an amount, from which their food will be paid for, etc. The *rancho* captain has the keys and amongst them, they take turns to be the cook. Each *rancho* is given a tub of water for a certain time. Different *ranchos* are given different hierarchies without mixing sailors, officers, and cabin boys. Although sometimes they make an exception". It is worth mentioning that within the vocabulary there are some confusions in certain definitions, such as in the case of *Manga*: it is the height on the sides of the ship, from the first deck to the edge; he is referring to the *Puntal del navío* since the definition should be something like this: the measurement of the beam is in the main deck, from one side to the other, through half the length; according to the 1722 vocabulary. There are also some interesting mix-ups such as *Amainar*: the same as *arriar*. *Arriar*: the same as *barras*. *Barras*: long masts that go through the holes in the capstan to turn it around.

3 Conclusions

Finally, in conclusion to this brief introduction to Ledesma's maritime vocabulary, I will say that this is one of the few ever compiled since the sixteenth century and it is the second known contribution of its kind with regard to New Spain. It is unique and it is not based on any previous works; it is, therefore, clear that it is the product of the author's life experience. This can be appreciated through the analogies he employs as in his omissions and mistakes. For instance, when he describes the decks: "they are like the roof of a house". Ledesma extolled his tale with the terms that he picked up on his journeys and wrote them down as a reference, both to render his discourse intelligible and for educational purposes. The set of terms that he put together tells us about a specific era of transatlantic sailing and it captures a collection of words picked up by a curious and savant traveller, although not an expert on nautical matters. However, as a whole, they allow us to discover certain aspects of the *Carrera de Indias*, sometimes in greater detail than in specialized works of the time, due to the author's terrestrial, non-maritime condition. Other works and research will fulfil the task of gathering more information on Ledesma, as well as examining closer the vocabulary present in his writing, for here I have but completed the basic requirements for an introduction. Thereby, it shall be imperative to develop a more profound analysis of its content in the future and exhaustively compare and contrast it to other vocabularies.

Acknowledgements I would like to thank Filipe Castro as well as the other editors, in the process of translating the vocabulary, their help was of the utmost importance. Also, to Mateo and Filipa for their patience and love.

Vocabulary

Note: Terms are accompanied by an equivalent in English when possible, and to the closest meaning when found. After the definition given by Ledezma, a translation is given.

A

Aparejo (*lifting gear*): es un cabo grueso puesto con dos motones a modo de carrillos en una entena con el cual suben al navío toda la carga. *A thick cable running through two blocks on a spar, with which all cargo is lifted onto the ship.*

Aparejar (*to rig*): es poner en su lugar toda la jarcia y lo demás del navío. *To put all the rigging and other equipment in place on a vessel.*

Amuras (*tacks*): son unos cabos gruesos en los puños de la vela mayor y del trinquete que tienen las velas para caminar a la bolina. *Thick cables tied to the main and foresail clews to hold the sails at close angles to the wind.*

Amantillos (*lifs*): son unos cabos que bajan de la gavia hasta los penoles para enderezar las vergas. *Cables that low (level) the topsail yards.*

Amantes (*boat tackle*): son unas betas gruesas de jarcia para meter y sacar del navío la lancha. *Thick cables used to load and unload the ship's boat.*

Acollador (*lanyard*): es un cabo delgado con que se atezan o estiran los obenques. *A rope threaded through a pair of deadeyes to adjust the tension in the shrouds.*

Andarivel (*life-line*): es un cabo desde el árbol mayor al trinquete por encima de las jaretas para que se tenga la gente cuando hay mares. *A cable running from the main to the foremast, above the gradings to support people in bad weather*.

Arriar (*hawl down*): lo mismo que botar. *The same as lowering.*

Amainar (*to strike*): lo mismo que arriar. *The same as* arriar.

Ayustar (*to splice*): es amarrar el cable en el anillo del ancla. *To tie the anchor cable to the anchor ring.*

Arpeo (*grapnel*): es un rezón de hierro que va debajo del bauprés con dos o tres garfios para atracarse los navíos y puede servir de anclilla. *An iron grapnel that stands under the bowsprit, with two or three hooks, to grab other ships and that serve as an anchor.*

Atracar (*to come alongside*): es asirse dos embarcaciones. Tie two vessels side by side.

Ancla (*anchor*): es un hierro gruesísimo de esta forma [figura]. Sirve para dar fondo. *A very thick iron in this shape (figure) that serves to anchor.*

Adala (*water chute*): es un bolsón por donde echa el navío el agua que saca la bomba. *A bag through which one drains the pumped water.*

Árbol mayor (*mainmast*): es el que esta en medio del navío; llamase mayor, no solo porque excede a los demás en altura y magnitud, sino también porque es el principal para el gobierno y seguridad de la embarcación. *The mast on the middle of* *the ship; called main, not only because it is larger than the others in height and thickness, but also because it is the main mast for the governance and safety of the ship.*

Árbol trinquete (*foremast*): es el árbol derecho que esta en la proa; también es muy necesario no solo para sustentar las velas grandes, sino también porque en las tormentas se aferran las velas todas; y solamente queda para gobernar el navío la vela del trinquete. De aquí tomo su origen aquella frase, cuando para decir que una persona tiene trabajos, decimos que anda corriendo con el trinquete, porque cuando anda el navío de este modo esta en la tormenta. *It is vertical mast on the bow; it is necessary not only to support the sails, but also because in storms all sails are reduced and only the foresail is used to steer the ship. This is where the phrase originates from, when we say that a person has problems, we say that she is running with the foresail, because when the ship runs in this way it is in a storm.*

Árbol de Mesana (*mizzen mast*): es el que esta a popa y no es tan grueso como los pasados, porque la verga mastelera y vela que carga son más ligeras. *The aft mast, which is not as thick as the previous ones, because the yard and the sail that it mounts are lighter.*

Árbol Bauprés (bowsprit): es el que va en la proa y lleva su verga, vela y mastelero; es muy necesario para que levante de prisa el navío y no lo sumerjan los golpes del mar, esta como nariz del navío y con propiedad, porque mediante este árbol saca el navío la cabeza y respira. *The mast that goes on the bow and carries its yard, sail, and topmast; it is necessary so that the ship's bow can be lifted quickly and not be submerged by the hits of the sea, it is like the nose of the ship and this with property, because through this mast the ship takes its head out and breathes.*

Artillería (artillery): son unos cañones muy gruesos de bronce y son los mejores o de hierro, y están sobre unas ruedas de madera pequeñas puestas como carro, y les llaman cureñas; estas las tienen aserradas contra la manga del navío con unas sogas gruesas que llaman aparejos, y con otras mas delgadas; tienen aserrada la pieza en unos garfios contra la misma borda, y a estas llaman palanquines. Los cañones de hierro con facilidad revientan, y hacen mucho estrago, por lo cual el condestable (a quien toca el cuidado de la artillería) tiene cuenta que los artilleros limpien con unas varas largas, y en las puntas envueltos unos pedazos de salea que llaman lanadas todos los cañones por el alma de la pieza (así llaman la parte de adentro del cañón) y le quiten los escarabajos que son unas postillas u hojas que hace la pólvora con la continuación de los tiros, como sucede en las lenguas de las campanas. Cada una de las piezas tiene hecha su medida de carga en unos como tanatillos de cartón, o madera, que llaman cartuchos, y cada uno de estos tiene su numero correspondiente al de la pieza porque no se truequen. Ay diversas fabricas y forma de artillería, y así tienen diversos nombres. Unas son de batir y hacer bala muy gruesa. Otras son culebrinas y son para lo largo. Otras pedreros pequeñas etcétera. Dáseles fuego en los serpentines con unas cuerdas envueltas en unos palos pequeños como de a tres cuartas que llaman (stained) (ilegible) para la (stained) (ilegible) ta, o vara en (stained) (ilegible) Al lugar (stained) (ilegible) va la artillería (stained) (ilegible) al combes andana alta, y a la que va entre puentes andana baja. Salen del navío las bocas de los cañones por unas ventanillas, que llaman: portas, y cuando la artillaría va vuelta están las portas cerradas hasta que es necesario echar la artillería fuera; a esto llaman abocar. De suerte que cuando van cerradas las portas, parece que el navío no lleva artillería alguna, y en estando a tiro, instantáneamente alza las portas, y aboca las piezas, que parece puercoespín. A la parte en que van aserradas las piezas que están seguidas en las andanas, llaman mura, que son como las paredes de las casas. *The large cannons of bronze, which are the best, or of iron, standing on small wooden wheels placed like in a cart, and called gun carriages; they are fastened against the side of the ship with thick cables, and with other thinner ones, called train- and breeching-tackle; they have the gun tied to hooks on the ship's hull, which they call gun-tackle. Iron cannons easily burst and cause a lot of damage, for which the constable (who takes care of the artillery) has to make sure that the artillerymen clean with long sticks, and in the tips wrapped some pieces of salea that they call mops, all the guns' cores and remove the powder lumps formed during long military campaigns. Each of the pieces has its own load measurement made in cardboard or wood tanatillos (cartridges), and each of these has its number corresponding to the piece so that they are not mixed. There are various shapes and forms of artillery, and thus they have different names. Some are to beat and throw a very thick ball. Others are culverins and are made for long shots. Others are small stone throwers,* etcetera. *Guns are fired with coils of rope wrapped in small sticks of about three quarters called (stained) (illegible) for the (stained) (illegible) …ta or stick in (stained) (illegible). To the place (stained) (illegible) goes the artillery (stained) (illegible) to the upper part of the deck (upper battery), and the guns on the lower deck (lower battery). The muzzles of the cannons come out of the ship through some gunports, and when the artillery goes inside, the gunports are closed until it is necessary to put the artillery out; This is what they call abocar. So that when the gunports are closed, it seems that the ship does not carry any artillery, and in being within range, it instantly raises the ports and brings out the guns, and it looks like a porcupine. The part in which the pieces are placed, in rows, is called mura, which are like the walls of houses.*

B

Baos (*crosstrees and trestletrees*): son cuatro palos cruzados en las puntas de los árboles sobre los cuales se asientan las gavias. *Are four timbers crossed over the mast tops, above which the tops are set.*

Babor (*port side*): es el costado del navío sobre mano izquierda. *The side of the ship on the left hand.*

Barras (*capstan bars*): son unos palos largos que se atraviesan en los agujeros del cabrestante para voltearlo. *Large timbers that cross the holes of the capstan to move it*.

Bertellos (*parrels*): son unas bolas de madera ensartadas como cuentas y metidas en los árboles en las cuales están amarradas las vergas para que suban y bajen mas fácilmente. *Wooden spheres mounted like beads on a rope that run along the mast and are used to tie the yards in a way that makes it easy to lower and hoist them.*

Bombas (*pumps*): son unas vigas gruesas y huecas por las cuales desaguan el navío. *Are large and hollow beams through which water is extracted from the ship.*

Bigotas (*deadeyes*): son unas bolas de madera chatas y redondas con unos agujeros por donde entran los cabos y los llaman acolladores. *Round timbers with holes through which cable run and tense the shrouds.*

Barredera o **Boneta** (*bonnet*): es un pedazo de lona que se añade a la vela que ande mas el navío. *A piece of canvas that is added to the foot of a sail to give the ship more speed.*

Borriquete de proa (*fore topsail*): es el velacho; así se llama la vela que va en el mastelero del trinquete. *It is a topsail; this is how the sail mounted over the bowsprit is called.*

Brazas (*Braces*) y **Bolinas** (*bowlines*): son unos cabos para poner las velas según el viento. *Cables to tune the sails to the wind.*

Barón o **Braguero del timón** (*rudder chains*): es un pedazo de calabrote, que los atraviesa por un agujero, y tiene las dos puntas amarradas en unas argollas pendientes de dos pernos muy gruesos, uno de cada lado para que, si se quebrasen los machos de hierro en que esta metido, o se saliere de ellos (que uno u otro sucede muchas veces con golpes de mar) no caiga el timón al agua, sino que se quede pendiente del Barón, o Braguero. *A piece of cable, which runs through a hole, and has both ends tied in hanging rings with two very thick bolts, one on each side of the rudder so that, if the gudgeons and pintles break, or if the rudder comes out of them (which happens many times with rough seas) the rudder does not drop into the water, but rather stands hanging from this cable.*

Brandales (*backstays*): son unos cabos con que se aseguran los masteleros. *Cables used to secure the masts.*

Boliches (*bowlines*): son lo mismo que bolinas. *Cables to tune the sails to the wind.*

Burro de Mesana (*brace*): son las amuras o cabos gruesos en que estriba la punta de la verga. *Cables to tune the sails to the wind.*

Brioles (*buntlines*): Son unos cabos con que se recogen las velas. *Line with which one pulls the sail towards the yard.*

C

Calar Mastelero (to lower a yard): es bajarlos de suerte que quedan colgados en parejo del árbol. *To lower the yards in a way that makes them parallel to the mast.*

Chapuces (–): son unas tiras o piezas de madera largas y angostas con que se engruesan los árboles y cogen de arriba a abajo del árbol. Solo el mayor y el trinquete tienen esto porque han de ser gruesos y no puede haber biga tan gruesa como es menester. *Long and narrow strips or pieces of timber with which the masts are thickened, from the top to the bottom of the mast. Only the main and foremasts have* *this reinforcement because they have to be thick and there cannot be a single timber as thick as necessary.*

Cable (*anchor cable*): es una maroma muy gruesa con que se da fondo al navío. *A strong cable to anchor the ship.*

Calabrotes (*smaller anchor cables*): son unas maromas como la mitad del grueso del cable que sirven de lo mismo que él. *Thinner, for instance, with half the thickness of the anchor cable that is also used to anchor.*

Cajeta (*sheet*): es un cabo ancho con que se aferra vela contra la verga; aferrar, es lo mismo que amarrar. *Cable with which the sail is tied to the yard.*

Coronas (*pendants*): son unos cabos puestos en circulo de los remates de los árboles y peñoles. *Cables laid in circle on the top of the masts.*

Chafaldetes (*clewlines*): son unos cabos para izar contra las vergas los puños de la gavia y velacho. *Cables used to lift the clews of the sails in the direction of the centre of the yard.*

Cabrestante (*capstan*): es un torno grueso para levar anclas y otras funciones. *Thick drum to raise anchors and other functions.*

Cazar (–): tirar la escota para marear las velas. *To tighten the sheets of a sail.*

Cámara de popa (*stern castle*): un cuarto grande a modo de sala según la capacidad del navío en la cual van comúnmente los pasajeros de mediano porte. *A large room like a living room where the passengers are lodged.*

Camarote (*cabin*): es un aposentillo en que va uno o mas, según el convenio con su puerta y llave; se hace o en la cámara o a los lados del alcázar que es aquella parte del navío que hay de la puerta de la cámara hasta el fin del pavimento de la toldilla. *A small room where one or more passengers are lodged, with door and key. It is made in the part of the deck abaft of the mainmast and forward of the stern castle.*

Catre (*bed*): es donde se duerme y son de dos maneras: unos fijos hechos de tablas y otros movibles de cordeles en cuatro palos y colgados de las esquinas. *Where one sleeps and are of two types: fixed, made with planks, or removable, made of ropes on four wooden sticks and hung from the corners.*

Combés (*deck*): es la cubierta superior del navío y coge desde el fin del alcázar hasta el castillo de proa. Aquí se hacen todas las faenas, porque es como el patio de las casas. *The upper deck, from the stern to the forecastle, the place where all tasks are carried on, like in the patios of houses.*

Castillo de proa (*forecastle*): es un tabladillo que esta delante del trinquete y coge de banda a banda en cima del cual va fijo el pie del bauprés. Ahí debajo sirve de despensa con su puerta (y llave para los trastes de el navío) en este castillo van muchos ranchos anchos de marineros, y de noche ay guardia. *A platform fore of the foremast and on top of which the foot of the bowsprit is anchored. The space underneath serves as pantry with its door, in this space lodge many sailors and there is a guard here in the night.*

Cubiertas (*decks*): son como los techos de las casas, y hacen divisiones de altas y bajas; y el combes viene a ser como la azotea por ser la ultima. *Like the roofs of the houses, and they make divisions in them, and the main deck is the terrace, being the last one.*

Caña de timón (*tiller*): es una viga grande que sale desde la cabeza del timón y atraviesa por la cámara baja que se llama limera, hasta que llega a ponerse igual con la bitácora y desde arriba baja el pinzote y la coge por la punta. *A timber that ties to the head of the rudder and crosses the lower chamber to the level of the binnacle, where it is tied to the whipstaff.*

Corredor (*veranda*): es como un grande balcón volado con su techo y todo lo demás abierto que sale por la popa fuera del navío; entrase a el por la cámara de popa. *Like a large balcony with a roof and all the rest open that protrudes from the stern and is accessed through the stern castle*.

D

Deloó (*to reach*): es lo mismo que orza, esto es, poner la proa contra el viento para ganar barlovento. *The same as reaching, to put the bow to the wind*.

Drisas (*halliards*): son dos cabos o maromas muy gruesas con que se izan, o arrían, esto es, suben o bajan la verga mayor y el trinquete. *Cables used to hoist and lower the mainsail and foresail yards.*

E

Estribor (*starboard*): es el costado del navío de mano derecha. *The side of the ship on the right hand*.

Eslinga (*sling*): es un cabo con que se ata lo que se ha de subir al navío con el aparejo y candeleta que es un motón o carrillo con un garfio grueso de hierro. *A cable with which one ties cargo to lift to a ship*.

Escota (*sheet*): es un cabo grueso con que tiran las velas hacia popa. *A cable that secures the clew of the sail in the direction of the stern*.

Estaies (*forestays*): son dos cabos gruesos conque se afianzan por la proa el árbol mayor y el trinquete. *Cables with which the masts are secured forward*.

Entenas (*spars*): son las vergas. *The yards*.

Escandallo (*sounding lead*): es una pesa de plomo para sondar. *A lead weight to sound the depth*.

Esquife (*skiff*): es la lancha o el bote. The ship’s boats.

Escobenes (*hawse holes*): son dos portas o agujeros que tiene el navío en la proa por donde salen los cables cuando se da fondo. *The holes in the bow for the anchor cables*.

F

Flamear (*to rustle*): es cuando las velas baten contra los árboles. *When the sails hit the masts.*

Filásticas (*yarn*): son los cordelillos delgados que quedan cuando se destuercen los cables. *The thinner yarns that make the larger cables*.

Farol (*stern lantern*): es una linterna de vidrio que va sobre la toldilla en la cual las noches obscuras ponen luz todos los navíos por no encontrarse; la capitana la pone siempre para que la sigan. *A glass lantern placed on the stern castle and is lit in the dark nights; the capitana keeps this light on every night so that the other ships may follow*.

Fogones (*ovens*): son dos cajones grandes de madera con sus techos donde se hace lumbre para la comida y al ponerse el sol se apagan y no queda más lumbre que una cuerda encendida en el mismo fogón; y esto toda la noche un hombre de guardia. *Two large wooden boxes with their roofs where fire is made to cook, and where the fire is extinguished at sunset and kept just as a burning yarn, and always with a guard.*

Faginas (*chores*): son todas las obras en que se ocupa el común. *The shores that the common people do*.

G

Gancho (hook): es un garfio conque se ayuda a tirar las velas para amurarlas cuándo ay mucho viento. *A hook used to gather the sails when they are furled due to strong wind.*

Guindar (*to hoist*): es levantar cabos de abajo a arriba. *To raise cables from below upwards*.

Guindaleza (–): es un cabo grueso y largo que traen los navíos por lo que se ofreciere. *A thick and long cable kept for when it is necessary.*

Guindastes (*cranes*): Son unas vigas gruesas que tienen en las cabezas unos huecos con sus roldanas por donde entran las trizas para subir y bajar las vergas. *Thick beams with holes on the upper extremity, with sheave blocks are inserted to hoist and lower the yards.*

Garrar (*drag*): es cuando echan la ancla y no tiene en el fondo con que hacer fuerza para detener el navío, y lo van arrastrando. *When an anchor does not grab the bottom and is dragged by the ship*.

Gindalete (*pump handle*): es un palo largo con que se le da a la bomba. *It is the handle used to operate the pump*.

Guardin (–): es un motón o carillo por el cual ensartan un cabo grueso para sujetar el pinzote cuando ay mucho mar. *A block through which a rope is passed to fasten the whipstaff with bad weather*.

Grajau (*rowle*): es un palo pequeño y grueso con un agujero donde esta metido el pinzote. *A timber short and thick with a hole through which the whipstaff passes*.

Gavias (*tops*): son unas ruedas grandes de madera en los remates de los árboles. *The large circular wooden platforms on the top of the masts.*

Guarda timones (*stern chasers*): Son dos cañones de artillería que están a los lados del timón. *Two guns placed on both sides of the rudder*.

Galafatear (*to caulk*): es meter estoperoles que son unos macillos de estopa en las costuras del navío, esto es, en las junturas de las tablas con unos escoplillos de hierro a fuerza de golpes y después le echan alquitrán y pez, que llaman carenar. *To put caulking in the seams between the hull planking with special chisels and after that to pour bitumen on the seams*.

Guarnir (*to serve*): es envolver los cabos con alguna cosa para que unos con otros no se ruyan o rosen. *To wrap the cables with materials that protect them.*

Y

Ymbornales (*scuppers*): son unos agujeros a modo de cañas que hay en el combes por donde limpian el navío. *The holes in the decks through which the ship is clean (emptied).*

Yzar (*hoist*): es levantar. *To raise*.

J

Jaretas (*grates*): son unas gruesas celosías que están en la boca de escotilla, y escovillones para que pueda entrar luz debajo de cubierta y no caiga la gente que anda por el combes. *The thick grids placed on the hatches and trap doors, so that light may pass to the lower decks*.

Juanetes (*topgallants*): son unos masteleros pequeños con sus vergas y velas que ponen sobre los masteleros principales los navíos zorreros que andan poco. *The small masts with its yards that are added to the rigging of slow ships*.

Jardines (–): Son unos corredores cerrados con sus ventanillas metidos en la misma popa. *The closed corridos with windows that are located in the stern*.

L

Lantia (*binnacle light*): es una lámpara fija que esta en la bitácora para que el timonero vea de noche la aguja. *A fixed light placed in the binnacle to allow the tillerman to see the compass*.

Lampaso (*mop*): es un fregador de filásticas atadas en un palo para lavar el navío. *A bundle of yarns tied together to mop the ship*.

Levar (*to hoist*): es lo mismo que subir, jalar, estirar. *The same as to hoist, to pull, to stretch*.

Liebres (*parrel ribs*): son unos palillos largos que están ensartados entre los vertellos para izar o arriar con facilidad las vergas. *The wooden planks inserted between the parrels to ease the hoist of the yards*.

M

Masteleros (*top masts*): son unos palos largos puestos sobre los árboles con velas y vergas y toma cada uno la denominación según el árbol en que va. *Verbi gratia* el mastelero que va sobre el árbol mayor se llama: mastelero mayor, etcétera. *Masts placed on top of the main masts with yards and sails, and which take the name of the mast on top of which they are fixed*.

Manga del navío (*beam*): es la altura que tiene por los costados desde la primera cubierta baja hasta la borda. *The height from the lowest deck to the caprail*.

Mesas de guarnición (*chainwales*): son unos tablones que tiene el navío en los costados, con unos pernos y cadenas muy fuertes de las cuales están pendientes con unos gruesos cabos las vigotas para los obenques de los tres árboles principales, mayor, mesana y trinquete: de suerte que cada árbol de estos tiene una mesa de guarnición por banda conque por todas son seis. *Thick planks placed on the sides of a ship with irons and chains to which the lower deadeyes are fixed, on the three more important masts: fore, main, and mizzen, so that there are six chainwales*.

Motones (*blocks*): son unos carrillos redondos y embreados. *Round blocks protected with bitumen*.

Meollares (*robbands*): son unas trenzas hechas de filásticas para amarrar las velas contra las vergas y para otras funciones. *The braids made of yarn made to fasten the sails to the yards and other functions*.

Mortero (–): es un instrumento de la guarnición de la bomba mura del navío. Es lo mismo que manga. *A component of a ship's pump. Same as sleeve*.

O

Oratorio (*altar*): es la capilla donde se dice Misa y va todo recaudo para administrar los sacramentos algunos navíos la tienen fuera de la cámara de popa debajo del alcázar. Otros la tienen embebida en la misma cámara, de manera que desde adentro se puede oír Misa; y otros no la tienen, sino que en una mesa encima de la toldilla hacen altar cuando se ha de celebrar. *The chapel where mass is said and where all precautions are taken to administer the sacraments, some ships have it outside the stern castle, under the quarterdeck. Others have it embedded in the same chamber,* *so that mass can be heard from inside, and others do not have it, but make an altar on a table on top of the awning when it is to be celebrated.*

Obenques (*shrouds*): son unos cabos gruesos que aseguran los árboles por las bandas del navío y salen desde las mesas de guarnición hasta la gavia; sirven también de escala para subir y bajar a las faenas porque atraviesan con unos cabos más delgados que se llaman: flechastres, de suerte que están formados unos seguros escalones. Los masteleros tienen lo mismo y sus obenques salen desde la misma gavia hasta el tope por los cuales suben los gavieros a registrar el mar o a divisar tierra. *Thick cables that secure the masts to the sides of the ship and come out from the chainwales up to the tops of the masts; they also serve as a ladder to go up and down to execute work aloft, and they have thinner ropes that are called: ratlines, in such a way that they form safe steps. The topmasts have the same and their shrouds go from the tops of the lower masts to the topmast tops, by which the sailors go up to search the sea or to look out for land.*

Orinques (*buoy rope*): son unos cabos en que se atan las boyas que son unos trocillos de madera y la otra punta del orinque se amarra en el ancla. Con esto, cuando se da fondo como la boya esta sobre el agua pendiente del orinque se conoce el lugar donde esta la ancla. *Cables tied to the anchors and to a buoy, which is made of small pieces of wood and, when the buoy is on the water it shows the place where the anchor is.*

Orza (*to reach*): es lo mismo que de loó. *The same as de loó.*

Ollaos (*cringles*): son unos agujeros que se hacen en forma circular a las velas. *Are circular holes on the edges of the sails.*

P

Popa (*stern*): es la espalda del navío. *Is the rear of the ship.*

Proa (*bow*): es la cara o punta. *Is the fase or front.*

Pairar (*to hover*): es cuando las velas están sueltas sin afirmarlas con las escotas, o amurar. También se llama trincar. *When the sails are flapping free.*

Papahigos (*main sail*): son la vela mayor y el trinquete. *The largest sail on the main and foremasts.*

Pinzote (*whipstaff*): es un palo largo cuya punta inferior se mete por el grajau y pasa a unirse con la caña del timón, y con este pinzote se gobierna. *A pole whose inferior end passes through the rowle and is fastened to the tiller, and with this whipstaff the ship is governed.*

Portas (*gunports*): son unas ventanillas con sus puertas por donde se avoca la artillería. *Are windows with their ports through which the artillery is deployed.*

Poleas (*fiddle block*): son dos motones unidos uno sobre otro. *Are two blocks united one over the other.*

Patesca (*single block*): es un motón para determinada faena. *Is a block for a determined task.*

Penoles (*yardarms*): Son las puntas de las vergas. *Are the tips of the yards.*

Popeses (*mizzen stays*): Son dos cabos para afianzar los árboles. *Are the cables to secure the mizzen masts*.

Q

Quilla (*keel*): lo mas bajo del navío. *Is the lowest part of a ship*.

Quadra (*stern panel*): la testera de popa. *Is the stern panel*.

R

Relinga (*bolt rope*): que también se llama testa, es como un muy grueso ribete que hacen a las velas por todas las orillas con filásticas para que no se rompan. *Also called testa, is like a very thick border that is made on all the edges of the sails with ropes, to prevent them from breaking*.

Roldanas (*sheaves*): Son las ruedas o carrillos de los motones. *Are the wheels of the blocks*.

Remos (*oars*): unos palos largos con que bogan en las galeras, lanchas y esquifes. *Long poles with which galleys, boats, and skiffs are driven*.

Remolque (*tow*): es cuando no ay viento para que puedan los navíos entrar o salir de los puertos, les amarran en la proa, unos cabos gruesos, y largos los cuales llevan amarrados en las lanchas, y a fuerza de remos los van tirando. Ay también otro modo de hacer esto, y es, que atan en un cable muy largo, una ancla, y la otra punta queda el navío; llevan luego la ancla con la lancha, hasta donde alcanza el cable, y la echan al mar después van tirando del cable con el cabrestante, hasta que llega el navío a la ancla: levan la otra vez, y vuelven a hacer la misma diligencia. Esto se llama espiar. En los ríos navegables es amarrar la embarcación con un cabo largo y desde la orilla de tierra la van tirando; esto se llama sisgar. *When there is no wind so that the ships can enter or leave the ports, they tie thick and long ropes to the bow, which they carry tied to boats, and by force of oars they pull them along. There is also another way of doing this, and it is that they tie an anchor to a very long cable, and the other end remains on the ship; they then take the anchor with the boat, as far as the cable reaches, and throw it into the sea, then they pull the cable with the capstan, until the ship reaches the anchor: they raise it again and do the same thing again. This is called espiar. In navigable rivers it is used to pull the ship from the margins with a long cable; this is called sisgar*.

Rebenquez (*cable to whip*): Son unos pedazos de cabo bien embreados con que hacen penitencia los grumetes y pajes que no cumplen con su ministerio. *Are pieces of pitched cable with which the cabin boys and pages who do not fulfil their work are punished*.

Rasqueta (–): es un hierro, por la una parte con su puño para cogerlo y por la otra ancho y torcido conque raspan la brea y escoria del combes y camarotes. *An* *iron, on the one hand with a fist to pick it up and on the other hand wide and twisted, with which they scrape the tar and slag from the decks and cabins*.

Rancho (–): es una compañía de 7 o más hombres, que da cada uno tanto y de esto meten la comida, etcétera. El capitán del rancho tiene las llaves y de ellos mismos cada dia se van siguiendo por cocineros. A cada rancho les dan una tina de agua para cierto tiempo. De cada jerarquía llevan ranchos distintos sin mezclarse marineros, oficial, y grumetes aunque tal vez dispensan en esto. *A company of seven or more men, who contribute each one with some amount and from this they make the food,* etcetera*. The captain of the ranch has the keys and from amongst them each day a cook is chosen. To each ranch they give a tub of water for a certain time. Each hierarchy has different ranchos without mixing sailors, officers, and cabin boys, although sometime they may dispense with this rule*.

S

Sondar (*to sound*): es reconocer las brazas de agua que hay desde la quilla al fondo. *It is to count the brazas of depth below the keel.*

Sondaleza (*lead*): es el cordel con que se ata el escandallo. *Is the line tied to the sound.*

T

Talla (–): es lo mismo que guardín, para gobernar el timón con fuerza de mar. *The same as guardim, to control the rudder in harsh seas*.

Timón (*rudder*): es una o dos vigas gruesas con sus pernos y goznes fortísimos para que vuelva de un lado a otro con el cuál se gobierna el navío mejor que un caballo con el freno. Va debajo de la cámara de popa en la testera del navío. *One or two thick timbers fastened with bolts and very strong hinges, so that it turns from one side to the other, with which the ship is steered better than a horse with the iron. It goes under the stern chamber at the stern of the ship*.

Tamboretes (–): Son unos palos fuertes en las puntas de los árboles con unos agujeros en que se ponen los masteleros. *Are strong timbers placed on the tops of the masts with hole to receive the top masts.*

Tomar por avante (–): es cuando el viento le da al navío por la proa y echa las velas sobre los árboles. *When the wind runs from the direction of the bow and pushes the sails against the masts.*

Toldilla (*stern castle*): es una cámara pequeña que esta en lo más alto del navío sobre la cámara de popa. *Is a small chamber that is on the highest level of the stern castle*.

Tajamar (*cutwater*): es un filo grande de madera que va en la proa y coge desde bajo del bauprés hasta la quilla, el cuál sirve de cortar el agua para que el navío pueda andar. *A large wooden blade that goes on the bow and runs from under the bowsprit to the keel and serves to cut the water so that the ship can move.*

V

Vandera de cuadra (*flag*): es la que se pone en la popa con las insignias reales para entrar y salir en el puerto en los días festivos, y cuando se mira tierra la primera vez. También se pone cuando se toma en el mar algún navío, y él la pide con un tiro de artillería. Si el navío es capitana lleva esta bandera siempre para que la conozcan en el tope del árbol mayor que es la punta del mastelero. Si es Almiranta, lleva la bandera en el tope del trinquete. Banderas de los topes son muy pequeñas, y las llevan todos los navíos en los remates, o puntas de los masteleros, estas banderillas se llaman grimpolas. Usan también de unas banderas muy largas y angostas de diferentes colores que llaman gallardetes, y ponen estas en los topes, peñoles y jarcia, y llaman empavezar. *A flag that is hoisted on the stern with the royal insignia to enter and leave the port on holidays, and when you look at land the first time. It is also hoisted when a ship is taken at sea, and he asks for identification with an artillery shot. If the ship is a capitana, it always carries this flag to be known at the top of the mainmast, which is the topmast. If it is an almiranta, it carries the flag at the top of the foremast. The flags of the tops are very small, and all the ships carry them there, or on flagpoles, these flags are called grimpolas. They also use very long and narrow flags of different colours that are called pennants, and they put these on the masts, yards, and rigging, and they call them empavezar.*

Veque (–): es la secreta de los navíos, y si es la embarcación grande lleva dos; uno en la proa donde lo llevan todos y otro en la cámara de popa para la gente grave.

Virar (*tack*): es volver el navío y dar vuelta encontrada. *To turn the ship.*

Vitácora (*binnacle*): es el lugar donde va la aguja. *The place where the compass is lodged.*

Velas (*sails*): son unos paños muy grandes de lona y tienen diferentes formas. La vela latina es larga y angosta y remata en punta. La redonda, es cuadrada. Ay otras velas que se llaman aletas. *Large canvas cloths with different shapes. The lateen sail is long and narrow and ends in a point. The round sail is square. There are other sails that are called aletas.*

Vela mayor (*mainsail*): la que va en el árbol mayor. *The one that goes on the mainmast.*

Vela de gavia (*topsail*): la que va en el mastelero mayor. *The one that goes on the main topsail mast.*

Vela de mesana (*mizzen sail*): la que va en el árbol llamado mesana. Es una vela triangular y lleva diversa postura. *The one that goes in the mast called mizzen. It is a triangular sail and is set differently from the others.*

Vela sobre mesana (*mizzen topsail*): la que va en el mastelero de la pasada. *The one that goes on the mizzen topmast.*

Vela trinque (*main foresail*): la que va en el árbol de este nombre. *The one that goes on the foremast*.

Velacho (*topgallant*): la que va en el mastelero del trinquete. *The one that goes on the fore topsail mast*.

Vela cebadera (*spritsail*): la que va en el bauprés. *The one that goes on the bowsprit*.

Vela sobre cebadera (*sprit topsail*): la que va en el mastelero del bauprés. *The one that goes on the bowsprit topmast*.

Vela encapillada (*full sail*): es cuando el viento las hecha sobre las vergas.*When the wind fills the sails on the yards*.

Vergas (*yards*): son unas vigas redondas muy gruesas que van atravesadas en los árboles y en ellas van puestas las velas. *Thick round poles that are hang on the masts and that carry the sails*.

Verga de gaza (*mizzen topsail boom*): es la que va en el árbol de mesana para cazar los puños de la sobre mesana, y ella por si no tiene vela. También se llama: verga seca. The one that goes on the mizzen mast to fast for the mizzen topsail and that stands by itself if there is no sail. It is also called *verga seca*.

Vstagas (*halyards*): Son los cabos con que se izan y arrían las vergas. *Are the cables used to hoist and lower the yards*.

X

Ximelgas (–): son unas lisias vigas gruesas de madera para engruesar el árbol mayor y el trinquete, y solo se diferencian de los chapuzes en que estos son de una pieza de punta a punta del árbol y las jimelgas son añadidas unas a otras. *Thick wooden beams used to reinforce the main and foremast and that only differ from the chapuzes in that these are made of one piece from one end of the mast to the other, and the jimelgas are added to each other*.

Z

Zalomar (–): es un tonillo que hacen los marineros cuando están en faena. A tone that sailors sing when they are working.

Zarpar (*to set sail*): es levar las anclas. *To raise anchors*.

Zabordar (*to run aground*): es encallar o dar con la popa entre tierra. *To ground the vessel from the Stern*.

Ziar (–): es remar a la contra para traer atrás la lancha retirándola sin virar. *To row abaft to bring the boat back without turning*.

Trades and Officers of the Ship

Capitán (*captain*): es el dueño del navío por cuya cuenta corre recibir los oficiales y pasajeros y meter todo lo necesario para el viaje. *Is the owner of the vessel at whose responsibility it is to receive the officers and passengers and to bring in everything necessary for the voyage.*

Capellán (*chaplain*): el que dice misa todos los días que no hay contratiempo; previene en el puerto bastantes hostias, vino y cera; cuida de los ornamentos y capilla; administra los Santos Sacramentos; tiene obligación de asistir al rosario todos los días; de hacer platicas espirituales; y sino supiere de rogar que las haga a otro sacerdote (si fuere en el navío) reformar juramentos, blasfemias, maldiciones, etcétera; cuidar de la comida y asistencia de los enfermos, y ser padre de todos. *He who says mass every day if there is no mishap; provisions enough hosts, wine, and wax at the port; takes care of the ornaments and chapel; administers the Holy Sacraments; has the obligation to attend the rosary every day; to give spiritual talks; and if he does not know how to, to ask another priest to do them (if he is on the ship) to reform oaths, blasphemies, curses,* etc.*; to take care of the food and assistance of the sick, and to be father of all.*

Piloto (*pilot*): gobierna el navío; da ordenes al contramaestre, observa los astros; previene el tiempo; vela de día, y de noche en la aguja y no debe fiarse de su ayudante, si sabe que no es experto. *He steers the ship; he gives orders to the boatswain; he watches the stars; he foresees the weather; he watches the compass by day and by night and should not trust his assistant, if he knows that he is not an expert.*

Maestre (*master*): es el que conchava la carga que ha de llevar el navío; que la entrega al contramaestre; en llegando a el maestre quien la entrega a sus dueños. *The one that adjusts the cargo that the ship will take; that delivers the orders to the boatswain; upon arrival he is the one who delivers the cargo to its owners.*

Contramaestre (*boatswain*): es el todo de un navío; el lo carga para que navegue bien; tiene las llaves de las bodegas; manda a toda la gente; lo que el piloto dispone, el contramaestre lo ordena; usa de un pito para todas las faenas; tiene facultad de castigar, y trae el rebenque. Todos cuantos van en el navío hasta el capitán mismo y los pasajeros le llaman nuestro amo: y por su mano se da la comida y bebida. *The master of a ship; he will load it so that it sails well; he has the keys to the holds; he commands all the people; what the pilot decides, the boatswain orders; he uses a whistle for all the tasks; he has the power to punish, and he carries the whip. All who are on the ship, even the captain himself and the passengers, call him our master; and by his hand is given the food and drink.*

Guardián (*boatswain's mate*): es como segunda persona o vicario de el contramaestre cuida de la limpieza del navío, y asiste el primero a todas las faenas. *Is like a deputy or vicar of the boatswain, he takes care of the cleanliness of the ship, and assists the boatswain to all the chores.*

Condestable (*constable*): gobierna la artillería y manda en el rancho de Santa Bárbara donde van los pertrechos de pólvora, balas, cartuchos, bosagos, y municiones; cuida de que los artilleros limpien los cañones y carguen las piezas. *Governs the artillery and commands the Santa Barbara hold where the gunpowder, bullets, cartridges, bosagos, and ammunition are stored; he sees to it that the gunners clean the cannons and load the pieces.*

Mayordomo (*Stewart*): da de comer, y trae las llaves de la limera (que es la cámara baja) donde lleva el capitán su rancho, dispone lo que le guisa en la cocina del capitán. *Provides food, and brings the keys to the limera (which is the lower chamber) where the captain keeps his food and arranges what he cooks for the captain in the captain's galley.*

Repostero (−): cuida de poner las mesas y el aseo de la ropa; da de beber, y reparte el agua. *Takes care of setting the tables and the cleanliness of the clothes, gives drink, and distributes the water.*

Despensero (*purser*): es el que da las raciones de menestras, que son legumbres, y pescado, biscocho y agua a la gente del mar, con orden y asistencia del contra maestre. *Is the one who gives the rations of vegetables, fish, biscuits, and water to the seafarers, with the order and assistance of the boatswain.*

Cirujano y **Barbero** (*surgeon and barber*): cuidan de untar, y asistir a los enfermos. *They take care of anointing and assisting the sick.*

Marinero (*seaman*): hace su cuarto de timón, y centinela de proa, y asiste a todas las faenas. *Makes his quarter at the helm, and sentry at the bow, and attends to all the tasks.*

Grumete (*ship's boy*): cuida al timonel, le da su cuarto a la bomba; limpia el navío y de todas maneras asiste a todas las faenas; en estando en el puerto anda con el remo en la lancha. *Assists the helmsman, makes his shift at the pump; he cleans the ship and, in any case, attends all the chores; when in port he rows the boat.*

Pajes del Navío (*pages*): lo barren, rezan las oraciones, pregonan las centinelas, llaman los cuartos del timón y sirven a la mesa. De estos pajes, uno es capitán de basura, otros de carneros, y otro de gallinas. *Sweep the ship, say the prayers, sail the centinelas, call the rudder's shifts, and serve at the table. Of these pages, one is captain of garbage, others of the rams, and another of the chickens.*

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Chapter 13
GIS Application for Sixteenth–Seventeenth Century Iberian Shipwrecks

Ana Crespo Solana and María José García-Rodríguez

Abstract This paper presents a new database creation and GIS application design concerning Iberian shipwrecks between the sixteenth and eighteenth centuries. This study is framed within the context of the project ForSEAdiscovery. The general objective is to cross-link historical information with dendro-archaeological evidence in order to date and provenance the wood used in Iberian shipbuilding and to provide a large amount of shared data through GIS-oriented databases that further analyses contributing to the definition of the Iberian ship as well as to the study of its construction evolution. This article describes the development of a GIS applied to maritime archaeology and history, with reference to information collected on the ForSEAdiscovery database, which has focused on ships, transoceanic voyages, and the use of wood for shipbuilding during the sixteenth to eighteenth centuries. It suggests new innovative ways of multidisciplinary research for historians, maritime archaeologists, forestry engineers, and others whose research may involve these topics, in order to take advantage of new technologies and to share information. The potential of database-oriented GIS in the study of maritime history is shown from the perspective of *geographically integrated history*. The use of GIS allows for interdisciplinarity in empirical research, dissemination of geo-referenced and historical data, and the experimentation with new methods of analysis.

The original version of this chapter was revised. The correction to this chapter is available at https://doi.org/10.1007/978-3-030-86460-6_14

A. Crespo Solana (✉)
Instituto de Historia, Consejo Superior de Investigaciones Científicas (CSIC), Madrid, Spain
e-mail: ana.crespo@cchs.csic.es

M. J. García-Rodríguez
Instituto Geográfico Nacional (IGN), Madrid, Spain

A. Crespo Solana et al. (eds.), *Heritage and the Sea*,
https://doi.org/10.1007/978-3-030-86460-6_13

1 Geographically Integrated History and Maritime Archaeology

The origin of the project arose in response to the demand for knowledge of the historical timber supply for shipbuilding between 1500 and 1800; the analysis of the mercantile networks that operated around the global timber trade, which was an imperial business, and shipbuilding policies and their relation to the channeling of forest resources. The empirical and highly transdisciplinary nature of the project demanded the integration of data produced into a geographic information system (GIS) as a visualization and data integration and mapping tool. One of the major bases of this investigation is the comparison between the historical information and the archaeological data gathered from already located and studied Iberian shipwrecks. Dendrochronological research focused on living trees and historic buildings in areas known to have produced timber for Iberian shipbuilding during the Early Modern Age provides complementary evidence for these past forest practices and exploitation. Additionally, the construction of tree-ring chronologies for these areas or regions may provide reference chronologies for the dating and provenance of timbers found archaeologically. The triangle of this multidisciplinary project is completed through archaeological investigation and timber sampling of suspected Iberian shipwrecks located in Iberian waters and beyond. As dendro-archaeological and historical data have been collected throughout the research stage of the project, the GIS-based ForSEAdiscovery Database has been utilized as an integration device for information, and as a visualization tool. This database has important precedents of which it is a practical and ideological extension. The projects DynCoopNet and GlobalNet (Crespo Solana and Alonso Garcia 2012; Crespo Solana 2014) have focused on defining interdisciplinary and epistemological frameworks for agents of historical analysis, trade networks, and natural resources. These projects offer a deeper understanding of commerce and maritime expansion during the First Global Age by combining information about agents, cooperation, sailing, maritime trade, trade routes, ports, and other entities essential to research.

One of the new research lines is the integration of these databases into a Historical GIS (or HGIS) (Gregory 2003; Knowles 2008). Currently, major technological advances in visualization and data integration allow for dynamic GIS applications to represent complex historical narratives and to provide a means of communication and dissemination of knowledge about the past events. The emergence of new technological forms has aided contemporary attempts to understand the past; yet even so, any such attempt must take the position of interdisciplinarity and collaboration. *Geographically Integrated History* (Owens 2007) has become a paradigm with focus on the understanding that historical processes require an integration of place, space, and time. Accomplishing this integration poses a challenge that can be met with modern information management, especially GIS, which has the ability to integrate different databases and types of sources (including tabular data, images, historical, cartographic, etc.) into a unique system for storing, managing, analysis, and visualization techniques, all of which serves to enhance knowledge. Historical GIS has the capacity to update information in real time. GIS permits historians, archaeologists, and other social scientists to treat each data type as a separate layer, which can be overlain by other data layers to see relationships among them. With the information organized in this format, researchers find it much easier to recombine and disaggregate data, in order to display selected features, explore what is known, expose unexpected relationships, and facilitate analysis of the interrelationships of multiple factors characteristic of challenging problems.

The main feature of GIS is to process geographic data from a large number of sources and integrate them neatly via a mapping project. It allows scientists who may have accumulated huge amounts of empirical data and information collected during years. GIS is a complex, dynamic, non-linear processes that require the organization of a large number of variables of a very different nature (in layers GIS), so you can identify those which are most involved in the stability of the transformations of the systems at any time and place. Other advantage is GIS facilitates linking and comparing places within different spatial scales. Particularly, when a place is a country or large region, it is difficult for a single historian to master what is known about multiple locations, and GIS provides an excellent platform for multidisciplinary collaboration among researchers. Finally, GIS permits visualization of relationships. Visualization reduces the cognitive weight on even the experienced analyst when the quantity of information is great, a problem is complex, and alternative solutions are numerous and exceed the capabilities of human reason. Maritime and nautical archaeology highlights the value of interdisciplinary processes due to their great potential for understanding the past from anthropological, historical, technological points of view. The subdiscipline of nautical or maritime archaeology arose in the early 1960s with the emergence and rapid development of technology, such as SCUBA (Self-Contained Underwater Breathing Apparatus). In more recent decades, this scientific branch has experienced numerous developments due to further innovations for scientific exploration of the underwater world in the fields of photography, computer science and electronics, geophysics, and robotics. These developments have occurred in response to the particular challenges that archaeologists and other researchers in the social and natural sciences have faced in establishing methods and techniques of exploration, excavation, systematic recording and interpretation of contexts, and conservation of materials when the area under study is submerged.

Thus, in the context of ForSEAdiscovery's scientific objectives, shipbuilding processes attested by the remaining structural materials in connection with the shipwreck acquire an important value. Currently, nautical archaeologists' methodologies are the same for land-based archaeology: artifacts are gathered and analyzed in context (and in situ) through survey and excavation and, when possible, through historical research. For the period between the sixteenth and seventeenth centuries, studies of shipwrecks have been focused analyzing the cargo along with other artifacts of historical and cultural value found in relation to the archaeological site. However, everything carried by the ship (cargo, crew, passengers, artillery, etc.) forms a contemporaneous set with the structure of the ship itself. When studied in this way, researchers can sometimes date the vessel through its construction materials (mainly wood and metals) very accurately. At the same time, such knowledge about the ship itself also provides information on several related issues, such as maritime trade routes, shipbuilding processes, shipboard life, and in some cases, the reason why the ship never reached its destination port. The structure itself is also an integral part of the historical narrative of the ship and can point to new theories about historic events that occurred throughout the Indies trade. When structural information of the shipwreck is established, it can be compared to historical documents preserved in the archives in order to identify the crew or the passage; inventory of goods transported (with its origin and destination, owner, property marks, prices); references to the artillery (foundry site, features, cost of parts); technical details of the ship (ship's history, construction data, repairs, construction plans); and even the types of economic activities developed around the various voyages and routes undertaken by the ship during its spectrum of life.

In addition to archaeological research, historical documentation alone references thousands of historic shipwrecks, representing a broad range of potential archaeological sites in need of legal protection by government authorities. Thus, combined archaeological and historical analyses are necessary to define strategies, not only for research and education but also for the protection of these invaluable cultural assets. Archaeological methodologies have infrequently included historical ones, at least in the study of shipwrecks from the fifteenth to seventeenth centuries. This historical period has attracted less attention of nautical archaeologists than those before and after it, although there is a PhD published by Denise Lakey (Lakey 1987), and a work about shipwrecks and maritime rescues in the "Carrera de Indias" during the seventeenth century published by F. Serrano Mangas (Serrano Mangas 1991). Subsequently, there have been significant archaeological surveys in areas such as the Bay of Cadiz and the Galician-Cantabrian coast (San Claudio 1997; Casado Soto 2000; Rodríguez Mariscal and Martí Solano 2001), where there are important remains from sixteenth to seventeenth centuries.

The new line of research under discussion here arises from an interdisciplinary methodology including GIS application, historical cartography, and nautical archaeology. Going even further than previous studies of this kind, ForSEAdiscovery has also integrated the scientific analysis of the origins of timbers used in shipbuilding. Dendro-archaeology, the science of the annual growth rings of trees to determine the date, chronological order of past events, and the geographical origin of the wood, is the final discipline whose methods and results allow for a successful interrogation of the forest resources for Iberian shipbuilding and, by extension, global expansion (Nayling, 2008). Therefore, the primary hypothesis is proposed with reference to the strong relationship between European expansion, shipbuilding, and deforestation in Europe and the Americas.

The research is focused initially on the Iberian world through the analysis of relationships between maritime expansion, the construction of an imperial state without centralization, and the economic demand for shipbuilding timber, all of which are questions related to ships that were machines of war and trade and were therefore the true social capital. The global timber trade emerged under these demands of forest resources and consequently, the destruction of trees, especially of the species oak (*Quercus spp.*) and pine (*Pinus spp.*) in this historical period. Advances in recent decades in disciplines such as nautical archaeology and wood provenance, i.e., the study of wood samples to determine their origins using tree-ring and geochemical analyses, among others, can lead toward the knowledge of ship timber origins, dates of construction, the consolidation of cartographic analyses, and 3D visualizations of underwater sites and shipwrecks (Nayling 2008; Steffy 2012; Domínguez-Delmás 2014).

One example of an interdisciplinary study employing dendro-archaeology analyzed the occurrence of hurricanes in relation to that of shipwrecks. One of the recent works focuses on North Atlantic tropical cyclone (TC) activity. The authors study it through a combination of tree-ring data and historical shipwreck data to show that TC activity in the Caribbean was distinctly suppressed during the Maunder Minimum (1645–1715), a period when sunspot activity and, therefore, solar irradiance were dramatically reduced (Trouet et al. 2016), resulting in colder temperatures in the Northern Hemisphere. A marked reduction of known shipwrecks in that period implies that there was a reduction in tropical cyclone activity (75% fewer hurricanes in the Caribbean) attributable to the Maunder Minimum.

2 GIS Applications in Maritime Archaeology: Background

Geographical Information System (GIS) is characterized essentially by the integration of different data types, which has enabled its successful use in many diverse disciplines. Archaeology has always had recognized the chronological and spatial dimensions of human behavior, so recent years have seen several examples of GIS applications. Because GIS can analyze and visualize spatial patterns between environmental and chronological variables in a simple and easy way, archaeologists have used GIS for the management of archaeological resources, excavation histories, landscape evolution, and prediction models for the location of sites. Underwater archaeology also includes several examples of GIS applications, including its use as a repository or catalog where information related to underwater deposits associated with an environmental variable, such as depth or nature of the seafloor, is stored. Similarly, GIS has been used to manage and display information from various geophysical sensors, and for analyzing historical-archaeological and oceanographic information to make predictions (Ryan and McGrath 2008). Still other GIS projects focusing on shipwrecks have been developed for improving the knowledge of underwater cultural heritage (UCH). Some examples are the MACHU (Managing Cultural Heritage Underwater) project that was developed as a three-year initiative (September 2006 to August 2009) involving seven countries and was sponsored by the European Union's Culture 2000 program. MACHU aimed to support better ways for effective management of UCH and to make information about common UCH issues accessible to researchers, policymakers, and the general public. One of

MACHU's outcomes was the development of a web-based GIS (MACHU GIS) application[1] for management and research.

The Geoportal *Archaeological Atlas of the 2 Seas* aggregates information about archaeological sites that lie beneath the English Channel and North Sea,[2] as well as sites situated on the foreshore, dating from prehistory to the present. Data related to underwater archaeological sites in Belgium, the UK, and France were combined to create a comprehensive database of the underwater archaeological landscape. This project was developed by Maritime Archaeology Ltd. and in collaboration with the Department of Underwater and Marine Archaeological Research (DRASSM) in France, with the close liaison of English Heritage (EH). The *Archaeological Atlas of the 2 Seas* was funded by the European Regional Development Funded (ERDF), INTERREG IVa 2 Seas Programme and was conducted to enhance our understanding of European submerged cultural heritage. The aim of this project was to learn more about maritime past by researching, discovering, and recording archaeology below European waters. Also a GIS database of shipwrecks in Australia was developed by the US government so that users can search for shipwrecks protected by territorial, state, or Commonwealth legislation.[3] In the USA, the Florida's Underwater Archaeological Preserves was developed by the US Department of State's Historic Resources Division, the agency in charge of protecting and promoting cultural resources in Florida and other states. They maintain a database of 11 shipwrecks found in this state's waters that have been declared as "museums in the sea."

The US's National Oceanic and Atmospheric Administration (NOAA) and its Office of Coast Survey maintains a Wrecks and Obstructions database that contains information on the identified submerged wrecks and obstructions within all US maritime boundaries. The data includes the position of each feature (latitude and longitude) along with a brief description and attribution. Information for the database is sourced from the NOAA Electronic Navigational Charts (ENC) and Automated Wrecks and Obstructions Information System (AWOIS).[4]

3 Historic Context and Iberian Shipwrecks

Studying Iberian Peninsula from the sixteenth to seventeenth centuries is an exciting challenge, which also involves the disciplines of history and other humanities, and GIS sciences, to help understand historic facts. ForSEAdiscovery has studied historic documents and extracted the information related to voyages made by

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1 http://www.machuproject.eu/index.html

2 Archaeological Atlas of the 2 Seas Project: http://www.a2s-geoportal.eu

3 Australia National Shipwrecks database: https://www.environment.gov.au/topics/heritage/historic-shipwrecks/australian-national-shipwreck-database

4 http://wrecks.nauticalcharts.noaa.gov/viewer/

Spanish for the three centuries in question. The development of such system has been explained in Chap. 3 of this book.

From the beginning, travel to the West Indies was a hard and dangerous adventure. A shipwreck was the worst threat because it was usually synonymous with death, especially when it happened away from the coast. The term "shipwreck" refers to the concepts, continent, and content of a ship: "the partial or total destruction of a ship at sea and a wrecked ship or part of such a ship." Therefore, the shipwreck synonymous with danger at sea and unfortunately, oftentimes with death. However, shipwreck is an *opportunity* to discover some of the most inaccessible areas of the social and economic reality of the past and even social behavior (Pérez-Mallaína Bueno 2015). Many shipwrecks happened during the ocean crossing, and almost always near a port (arrival or departure), which affected subsequent voyages. The causes of these disasters were many and diverse. The most frequent were due to storms, followed by human error and then by cases of grounding, collision with obstacles, overload, or fire. In addition to these causes, there were shipwrecks as a result of piratical attacks, and in time of war, enemy state attacks, although both were on a smaller scale than the aforementioned causes. Although shipwrecks were most often random accidents, sometimes were deliberately caused to provoke evil or to prevent further evils. From the beginning of Indies trade, mariners already knew what began to blow in the Gulf of Mexico after summer, and the terrible north winds in the Bahamas Channel threatened hurricanes. The scourge of the sea has always been the weather: storms, hurricanes, etc., which can bring real damage against ships moored in the harbor, and especially to those sailing at sea. In addition to storms and user errors, shipwrecks could also be caused by the poor condition of the ships, as those making the journey to the West Indies were often old and unable to withstand the pressures of water and wind. They often used the expression: *"go through"* or *"ir a través"* which refers to ships whose final voyage was to America where they would be scrapped stripped of everything that was profitable. Therefore, many of them because of their poor condition complicated by any contingency or problem did not reach the coast. Many of the crew and passengers were saved by one of the most marked characteristics of the Indies route, sailing in convoy, which allowed for another ship to transship the cargo and people in case of danger. According to Chaunu (Chaunu and Chaunu 1960), the accident rate was very low along the West Indies route, only 5% of vessels lost and cargo losses in tons. Chaunu identifies the places with the highest number shipwrecks: Veracruz, Matanzas, Bermuda, Azores, and Cádiz. On Iberian coasts, ships sank most frequently beneath the Guadalquivir River because only a highly skilled pilot could successfully bypass the obstacles that threatened the journey from Seville to Sanlúcar (Flores 1982).

4 Methodology

It is estimated that over three million shipwrecks are spread across ocean floors around the planet. To a large degree, the preservation of their remains depends on the environment, but if preserved, shipwrecks can provide precious historical information. A shipwreck is by nature testimony to trade and cultural dialogue between diverse peoples. Everything transported by ship as cargo, crew, passengers, artillery, and its own structure can, after the wrecking event, form an archaeological site on the seafloor as a result of one or several causes. The study of shipwrecks allows researchers to date with great accuracy the vessel and associated materials while providing information on topics such as maritime trade routes, shipbuilding, shipboard life, and the possible reasons why the vessel never reached its destination port. The archaeological analysis of wrecks has a great ally in the task of recovering the memory of our past: the historical documentation kept in archives, which is more accurate and plentiful the closer we come to more recent times in history. Beyond archaeological research, historical documentation is useful for other purposes. Historical documentation is useful in that it references thousands of historic shipwrecks, a large list of potential sites to be protected by competent government administration. Therefore, there is a need to define strategies, not only for research, but also for protection and for the dissemination of the values of these cultural assets. Most Iberian shipwrecks have been damaged by treasure hunters in search of artifacts with market value and that can be sold for profit. Shipwrecks that have been underwater for one hundred years or more are protected by the 2001 UNESCO Convention on the Protection of the Underwater Cultural Heritage. It represents the international community's response to the increasing looting and destruction of underwater cultural heritage. The recovery of the frigate *Nuestra Señora de las Mercedes* or *La Mercedes,*[5] as a cultural treasure, sunk by the British in the Portuguese Algarve coast on 5 October 1804, was the result of years of research into historical documentation. The frigate remained submerged in the sea with its cargo, until 2007 when the US company Odyssey announced its discovery of the wreck and plundered part of the cargo. At that point, a long judicial process ensued during which the Spanish government also claimed rights to the discovery. Ultimately, the dispute's resolution was found in the vast documentation that experts carefully studied in the archives of the Naval Museum in Madrid, the *Archivo General de la Marina* (Palacio de La Bazán), *Archivo General de las Indias*, among others.

[5] http://www.mecd.gob.es/fragatamercedes/inicio.html June 2016

4.1 Primary Sources: Archivo General de Las Indias, Seville

An essential methodological aspect in order to locate the material remains of shipwrecks is the study of historical references. Historical sources can be helpful to historians, researchers, and maritime archaeologists to locate a shipwreck or to know what occurred in the past in that precise location. These original sources include descriptions of voyages or accounts of shipwrecks in archives and old navigation charts. They can provide clues for researchers and archaeologists to know where they might find remains, or they can also help them to interpret a find.

The *Archivo General de las Indias* (AGI) in Sevilla (Spain) is responsible for the custody of the resources produced by the institutions created by the Spanish Administration for the government and administration of Spain's overseas territories. The aim of the Archive is to conserve these resources and, through their organization and description, encourage their dissemination to all citizens. The AGI is the most exhaustive and comprehensive source of Spanish shipwrecks, as it contains 49,000 files, 80 million sheets, 8000 maps, and 9 linear kilometers of shelves. The documentary capacity of the AGI, therefore, is of exceptional interest for the historical study of the Spanish presence in the Indies, affecting a huge area spanning the Americas (from the southern USA to southernmost Argentina at Tierra del Fuego) to the Philippines from the late fifteenth to late seventeenth centuries. Given the vastness of the documentary material, it is classified into 16 sections: *Patronato*, *Gobierno*, *Estado*, *Títulos de Castilla*, *Contaduría*, *Escribanía de Cámara*, *Ultramar*, *Tribunal de Cuentas*, *Contratación*, *Arribadas*, *Papeles de Cuba*, *Diversos*, *Justicia*, *Correos*, *Consulados*, *Mapas y Planos*. The section *Gobierno* is composed of fifteen subsections, fourteen of which are organized by "Audiencias" (Court of justice that deals with the causes of a certain territory in the Spanish West Indies) and the fifteenth labeled *Indiferente General*. The AGI is organized according to administrative criteria; therefore, when researching shipwrecks, the information is found in many different sections, each of which needs to be investigated in detail. In addition, the miscellaneous nature of the documents makes it a time-consuming task to gather the relevant information. Nonetheless, the AGI is key to the study of ships and their voyages. The so-called Records of Coming and Going *(registros de ida y salida*), which are documents belonging to the *Casa de Contratación* (or the House of Trade), are of top priority in the study of ships. Records from the House of Trade, the base of the entire organization of the Indies, are essential, including correspondence, Navy papers, masters' accounts, etc. The *Gobierno* subsection of *Indiferente General* has a great deal of documentation concerning fleets, the navy, and shipwrecks, all of which generated specific documentation. All the subsections of *Audiencias* also have data on shipwrecks, e.g., correspondence between viceroys, governors, presidents, etc., and these documents are important to the study of the fleets in the Americas. Also, documents from the sections *Casa de Contratación* and *Consulado* contain information on the fleets working along the Spanish coasts. The most important concept to discern in relation to a shipwreck is the cargo, i.e., what goods and how much was lost versus salvaged.

The geographic location of the sinking was considered less interesting, so many times the information in the documents is scarce or incorrect. The registers in the *Contratación* section report the name of the vessel, the master, sometimes the owner, its origin, and its destination, and if it suffered any setbacks, but all of this information is recorded in concise form. In this section are also found the reports, *registros de ida*, filed during the three visits made to the ships before leaving for the West Indies. These reports documented the description of the ship as well as an inventory of its artillery, equipment and luggage, tonnage, and cargo. The cargo was detailed: the consignor, the consignee, or the person to receive the cargo in his absence, and also private labels that identify each shipment, the goods, and its value. However, these data are not always reliable and were sometimes even intentionally erroneous. The name of the ship usually refers to a religious figure, and while the ship's name is retained over a long time, it may be referred to in a variety of ways because oftentimes there were multiple ships of the same name in a single convoy. So, for clarity, some ships would be referred to by a nickname or *alias*. As a result, researchers determining information on a specific ship are advised to search under the name of the captain of the fleet, the captain of the ship, the master, or the owner. Descriptions of the cargo hardly ever corresponded to the entirety because ships usually contained unregistered goods. Other types of information may be registered in the *averia*, receipts, and tax bills. In the *Consulados* section are registered lawsuits, such as court cases concerning the investigation of criminal acts in the loss of the ships, as well as salvage and trade-related documentation. In the *Justice* and *Escribania* sections, we find the appeals to these lawsuits and other information pertaining to all these investigations. We conclude this section on historical documentation by emphasizing that in almost all sections of the AGI there can be found precious data on fleets or shipwrecks. Through carefully scrutinizing the relevant documents distributed throughout the various sections of the AGI, it is possible to reconstruct the facts of history.

4.2 Searching Documentation: Website PARES

Historic shipwrecks are invaluable for scientific research. In particular, they are attractive to historians and maritime archaeologists because their remains preserve historical information and direct evidence of past events. They reveal scientific information about life and culture at that time. In this way, shipwrecks can be compared to time capsules, in that they provide a snapshot of life on board at the time of sinking. In the ForSEAdiscovery project, shipwrecks are studied to discover details about certain historical events, particularly in relation to shipbuilding, timber supply, goods, and trade routes. To gain these insights, we have consulted the most important and well-known Spanish website PARES (http://www.pares.mcu.es/) for searching and locating digitized historic documents. The Spanish Archives Portal is a project of the Ministry of Education, Culture and Sports for the dissemination on the Internet of the Spanish Documentary Heritage preserved in its network of centers. It is a dynamic open-access project that serves as a framework for other archival outreach projects of a public or private nature. PARES offers free access not only to researchers but to any citizen interested in accessing digitized images of documents within the Spanish Archives.

Fortunately, many of the millions of documents created in the past have been preserved, and they are today available for study. In Spain there are a number of archives that contain information with possible importance for shipwreck studies. Beside the AGI, historical documents are localized at the *Archivo Histórico Nacional, Archivo del Museo de la Marina* and *Biblioteca Nacional* in Madrid and the *Archivo General de Simancas* in Valladolid. As detailed in the section above, by far the richest source on the Spanish American colonies is the AGI, which is the central repository of documents related to the colonial administration of Spanish America. Through the PARES Spanish Archives Portal, it is possible to search information related to incidents that occurred on maritime voyages, especially shipwrecks. Using the PARES search engine, we used the advanced search and entered the following terms in Spanish: *naufragio* (shipwreck), *pérdida* (loss), and *hundimiento* (sinking) in order to locate registers about shipwrecks among all available digitized documents. Additionally, these terms were combined with the known name or *alias* of the ship with specific type of vessel, e.g., *nao*, *galeon*, etc.

Once we searched and found records related to shipwrecks, a more exhaustive search within the reference, or "signature": Signal that is placed on an object to distinguish it from others, especially the signal formed by numbers and letters that is placed on a visible part of a book or a document to classify it and indicate the place it occupies in a library or in a file. Signature is made, looking for all information relating to the loss of the ship or fleet (Fig. 13.1).

4.3 Names of Ships

The name of the ship is usually retained over a long period of time, but it can be written numerously. Thus, the names *San Juan Bautista, or San Juan* may all refer to the same ship. And, as explained above, multiple ships in the same convoy can have the same name, so they may be given a nickname or alias by which they are also known, e.g., *La Trinidad* appears as *La Quintera* after its owner Alonso Quintero. In another example, *Nuestra Señora de la Concepcion* (1708) is called *La Nieta*, after its owner Francisco Nieto. Therefore, to locate records pertaining to a specific ship, better results are achieved by searching with the owner or master's name, if known.

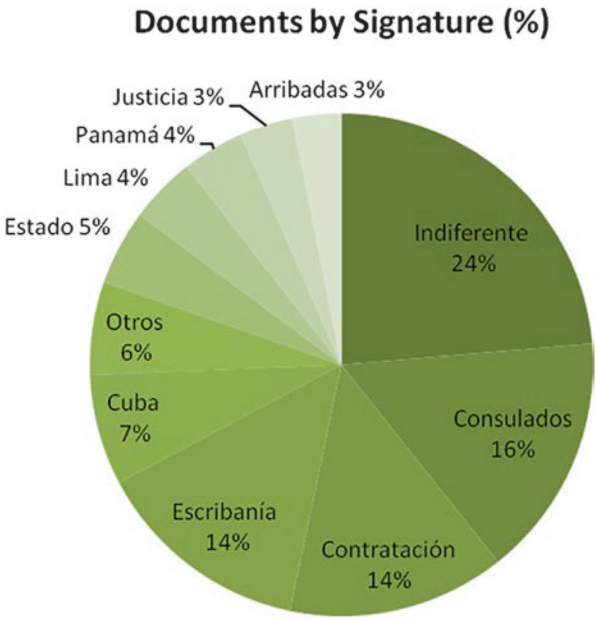

Fig. 13.1 Percent of AGI Documents related to "shipwrecks" classified by signature

4.4 Placenames (Locations) and Geographical Coordinates

Placenames change and disappear over time, so it is essential to have contemporaneous cartographic information from the time under study. In practice, once documentation of a shipwreck is located, we then conducted a search for the placename or site description in the archived files and antique maps. Most of the placenames correspond to old or unknown names and cannot be reconciled with current placenames. To resolve this issue, it is necessary to investigate the placename in other documents. These locations were corroborated in different ways, by looking through books and old maps, gazettes on the Internet, the geonames website (http://www.geonames.org/), and Google Earth. In doing so, we were able to find the geographical coordinates (latitude and longitude) for the majority of the placenames to display on the GIS application.

It required extensive research of each placename to link the documentary information on fluvial and maritime cultural heritage with historical sites. In the database, the literal description of the site of the incident or shipwreck is placed in association with the historic and cartographic source in the field "place." This information will allow us to know the origin and evolution of the names of certain locations and coastal landscapes, e.g., the place called *La Higuerita*, which is currently known as *Isla Cristina*. Also, it is relevant to know the many names of localities with reference to lows, hollows, reefs, and peaks in the sea or watchtowers inland, e.g., *Laja de Enmedio, Bajo del Diamante*, *Torre del Asperillo*, *Bajos de Salmedina,* or *Puntales.*

Some studies are based on comparative analysis of the different cartographic sources, which are analyzed diachronically through GIS, so that experts can accurately determine the evolution of the coast over the last two centuries. As was explained above, the study of historical textual sources is very important to characterize and determine various elements of maritime cultural heritage. But maps are particularly essential for determining the location and the distribution of this heritage in geographical space; therefore, they are also essential for developing strategies for investigation and preservation.

The secondary literature has been studied and reviewed, with particular attention paid to sources on shipwrecks during Atlantic voyages between the sixteenth and seventeenth centuries. These sources have also been incorporated into the ForSEAdiscovery shipwreck database.

4.5 Iberian Shipwrecks Database

The ForSEAdiscovery project aims to collect Iberian shipwrecks between the sixteenth and seventeenth centuries into a database to provide a basis for qualitative and quantitative analysis over time in a GIS application. Aside from the web mapping displayed in the GIS laboratory of the Consejo Superior de Investigaciones Científicas (CSIC) in Spain, several projects have been derived from this main objective as the Nautical Archaeology Digital Library supervised by Filipe Castro as a member of the ForSEAdiscovery Consortium.[6]

The preparation of the Iberian shipwrecks database has been an arduous task because documentary evidence found in the AGI collection is dispersed among different sections, and when located, the relevant information is sometimes scarce and particularly confusing for the first period of the study, between the fifteenth and sixteenth centuries. Regarding existing databases and documentation with reference to Iberian shipwrecks, we can refer to the extensive database of the Spanish Navy and Underwater Archaeology Centre in Andalucia (CAS). The Spanish Navy has estimated that there are thousands of shipwrecks distributed on the coasts of the Iberian Peninsula and the Caribbean islands. The Navy has set up a database to record all shipwrecks available in the naval archives. The project began in 2011 and continued during 2012 with the identification of 1580 shipwrecks. The aim of the project is the location and identification of documentary heritage in naval custody on Spanish Navy shipwrecks and related files, pertaining to Spanish vessels anywhere in the world, and sunken ships of other nationalities in Spanish territorial waters. The results corroborated the known data on the presence of most wrecks in areas including the coast of the Iberian Peninsula and the Caribbean, the latter a

[6] https://shiplib.org/

result of the intense maritime traffic maintained with America for over three centuries.[7] Of the 1580 registered shipwrecks, 75% (1176) were located. Classified by region, Europe accumulates 59.3% of the recorded wrecks, with Spain alone accounting for 596 shipwrecks, 50.7% of the total for Europe. Spain's total is followed by North and Central America and the Caribbean, where 26.7% (314) of the wrecks were tallied, most of them (176) off the coast of Cuba. South American wreck locations amount to 6.8% of the total (80); wrecks in the Pacific and Australia account for 5.4% of the total, with most of them (50) in the Philippines. Finally, in North Africa there is evidence for 21 wrecks. While 85% of records do not record the date of the wreck, they are also classified by century, with the majority (390) having occurred in the seventeenth century. In descending order, the twentieth century had 307, the seventeenth had 239, the sixteenth had 238, and the seventeenth had 147, and for the thirteenth to fifteenth centuries 16 shipwrecks were catalogued.

The Archivo de la Marina contains original documentation beginning in 1767, so the entries prior to that date are fewer and come from secondary literature and documentary sources. Naval historian, Cesáreo Fernández Duro published his work *Naufragios de la Armada Española* (Fernández Duro 1867), which includes official documents in the archives of the Ministry of the Navy. In the region of Andalucia, the project SIGNauta was developed by the Underwater Archaeology Centre in Andalucia (CAS) in 2000. Covering the area between the mouth of the Guadalquivir and the Bay of Cadiz, SIGNauta is the information system for the management of underwater archaeological heritage in Andalusia. It is a system adapted to the needs of management and analysis of underwater cultural heritage. The aim was to improve the protection of underwater cultural property in Andalucia by developing specific tools applied to its management (Alonso Villalobos et al. 2007). Other databases focusing on Galician wrecks have collected approximately 800 sunken ships dating to the sixteenth century. The database created by M. San Claudio (San Claudio 2000) is the first step toward creating an underwater archaeological chart of the Galician coast, between the mouths of the Eo and Minho rivers, within the 200-mile limit of the Exclusive Economic Zone. The information is collected from all literature available, ranging from newspapers to archives, and including personal interviews with fishers, skippers, ship salvage companies, and divers. The creation of a GIS-oriented database for shipwrecks and incidents on oceanic voyages from the sixteenth to seventeenth centuries the following process was carried out. The first step was searching information that registers shipwrecks and incidents. We have studied primary sources throughout Spanish archives, and further investigations were conducted into secondary sources. Second, we compiled all information related to voyages and shipwreck incidents into a GIS database. The database will be accessible through a Web-based GIS application and throughout a web mapping for visualization of both historical and archaeological shipwrecks by routes and functions.[8]

[7] Source: Spanish Navy: http://www.armada.mde.es/

[8] Developed at the CSIC: http://unidadsig.cchs.csic.es/sig/index.html

5 Database Structure

The fields within the Shipwrecks table contain basic identification data, location, chronological data, additional information, documentary information, imagery and attached documents. Sometimes, the ship's name alone is insufficient to distinguish ships from one another. Furthermore, there are many vessels with the same name within one year of navigation, even within the same fleet. Names such as *Nuestra Señora del Rosario*, *Nuestra Señora de la Concepción*, *San José*, *San Juan Bautista* are the most common and so in many cases these names refer to several different vessels. Sometimes, *Nuestra Señora* is omitted altogether, so *Nuestra Señora de la Concepción* is referred to simply as *Concepción* or *La Concepción.* Finally, a ship with a long name one whose name is shared with another in the same fleet would be known by a nickname or alias in the documentation. When the name of the vessel is not known, but there is information on the ship's master, captain, or General Captain, or its date, the name of the vessel is marked as "Unknown." Frequently, in the historical documentation, a ship is referred to by her fleet position only *(capitana, almiranta).* The *capitana* carried the General Captain (fleet commander) and usually proceeded at the head, while the *almiranta* carried the Admiral and was located at the rear. Therefore, it was necessary to develop criteria for distinguishing them, so we have chosen eight *Basic Identification Data:* ID_HShipwreck, Nameship, Alias, Typevessel, Fleet, GeneralCaptain, Captain, and Master.

The primary key *ID_HShipwreck* is a unique identifier and that made it possible to correlate with other tables in the model. The identification code is composed by the letter "S" and 4 digits, in function of ascending order in the list. It is an autonumber registration code. *NameShip* is the name of the vessel. *Alias* is the alternate name of the vessel if known. *Typevessel* is the type of vessel (e.g., galleon or frigate) indicated, and if only the generic terms *nao* or *navio* were used in the document, then those terms are entered in this field. *Fleet* is the name of the fleet, such as *Tierra Firme*, *Nueva España,* etc. Finally, General Captain, Captain, and Master are the names of General Captain, Captain, and Master of the ship, respectively. Other than the name of the ship, General Captain or Captain is the single most important item to distinguish ships from each other because many documents found referenced the name of the commander and not the ship. Some examples are *Galeones de Menendez Avilés* (1568) and *Flota de Miguel de Oquendo* (1663). Sometimes, only the name of the fleet is specified: *Flota de Tierra Firme* or *Flota de Nueva España.*

There are more fields in the database to allow for information such as location, date, and additional data. The field *Location* records the position of the site, description, or route of the ship (Latitude, Longitude, Place, and Route); *Chronological Data* records the date (year, month, and day); and *Additional Information* refers to reason of the incidence, number of deaths, tonnage of vessel, or convoy of the fleet as *capitana, almiranta,* or *gobierno* (Cause, incidence, DeathNumbers, TotalValue, Tonnage, Convoy). So the ship's size can also be a way to distinguish between two vessels of the same name.

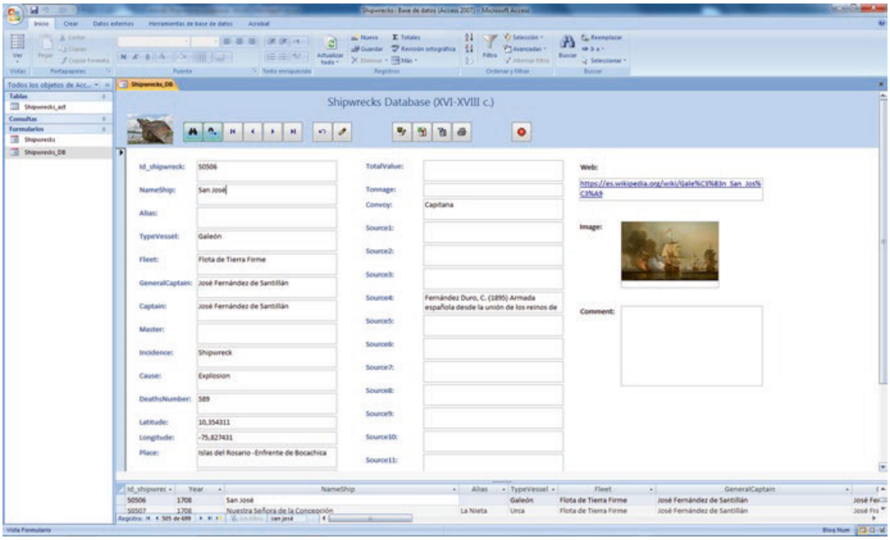

Fig. 13.2 Form of "Shipwreck_History" Database Access

Also, there is a list of sources and literature that corresponds with the information extracted and used for each event in *Documentary Information*. Finally, there are three fields with additional information: *Web*, where a web address is provided by Uniform Resource Locator (URL) to refer to a web resource that specifies its location on a computer network and a mechanism for retrieving it; *Image,* for adding an image of the ship, fleet, or event; and *Comment*, for adding further observations or more details of the event.

The database was created using Microsoft Access, which was user-friendly and allows for a great quantity of data to be placed and located conveniently. We created several buttons for database navigation (previous, next, first and last register, search) and for edition, new data, print, and save. With the form, we can show each register of the database as a card (Fig. 13.2). The form of the table "Shipwreck" includes a subform. It is a datasheet form that displays linked records in a table-like format, which is useful to search records by keyword, filters, or list of results.

6 Geographic Information System (GIS) Application

The backbone of a geodatabase is the data model, which consists of the conceptual formalization of the geographic features of the real world in order to make an abstraction which will satisfy the information needs. Implementation of the model should facilitate operation and optimize storage for best performance in queries.

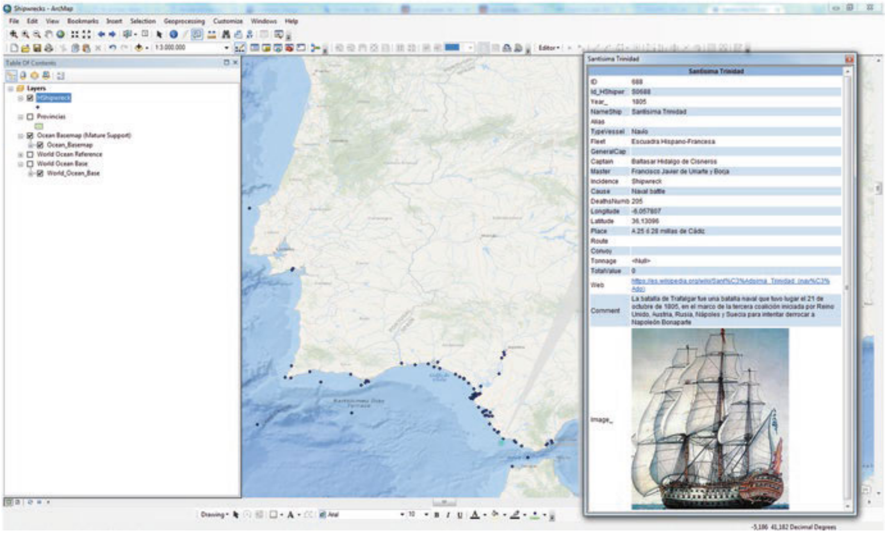

Fig. 13.3 View of "Shipwreck" GIS application developed under ForSEAdiscovery project

The geodatabase storage model is based on a series of simple, but essential relational database concepts and exploits the strengths of the underlying database management system (DBMS). Simple tables and well-defined attribute types are used to store the schema, rule, base, and spatial attribute data for each geographic dataset. This approach provides a formal model for storing and working with data.

The *Shipwreck geodatabase* has been implemented in a Geographic Information System for the context of ForSEAdiscovery project using ArcGIS 10.2 (software ESRI). This GIS application is developed for the management, exploration, and analysis of information and the representation of it through different maps and graphics. The layers of the GIS application are: *Base map* (Ocean layers, Topographic map, and Satellite imagery) and *Thematic map (*Shipwrecks).

6.1 Requiring Information

One of the ways of learning through the map is to know information about the layers. The GIS displays information about the shipwreck layer using a popup window. To do this with ArcGIS that contains feature layers, click on a feature to display information about it. The information is presented in a feature's popup window, which is generally based on the tabular information associated with the feature (Fig. 13.3). In other cases, historical maps, satellite images, aerial photography, GPS coordinates and images are used for completing the documentary history and information of a shipwreck.

7 Analysis of Shipwrecks Database

Experts estimate that there are nearly 3000 shipwrecks around the Spanish coast. History attests to the intense commercial relationship between Spain and the Americas established following the first landfall of Columbus. Between *Ayamonte* and *Tarifa*, *Guadalquivir Bar,* and *Seville* there may have submerged many of these commercial ships and fleets. The Underwater Archaeology Centre (CAS) estimated that off the coast of Cadiz and Huelva there are about 1500 sites, of which only 600 are already documented shipwrecks. In what follows, we summarize the data in relation to the Spanish and Portuguese coasts where important references to shipwrecks have been found. The Costa da Morte (Galicia) is an important site, and on its seafloor lie about 400 shipwrecks. This area and the dunes of Corrubedo have the most documented shipwrecks and represent more than half of the 2000 wrecks registered in Galicia.

Sanlúcar de Barrameda' sand bar is formed by the accumulation of mud, sludge, and other particles that are carried by the river current to this area. This accumulation of sludge, together with the effect of tides and winds, was in antiquity a dangerous passage for ships entering or leaving Seville, meaning that the captains who managed to overcome this "Bar" deserve some merit. In the case of Andalusia, there is a list of protected areas which are registered in the General Catalogue of the Andalusian Historical Heritage and Cultural Interest, with the type of Archaeological Zone (Decreto 285/2009, BOJA).[9] For example, the underwater archaeological sites in the province of Huelva are comprised of seven shipwrecks and three watchtowers: Torre del Río del Oro, Torre del Asperillo, and Torrre de la Higuera. These are included because their remains are fully or partially submerged. The Gulf of Cadiz is one of the areas where the greatest number of remains of sunken wrecks could exist according to experts and historians. The latest data provided by the Ministry of Defense confirmed between 500 and 800 ships have accumulated in the waters around Cadiz, 100 of which have been located. The Bajo de Chapitel site is located opposite the city of Cadiz, in the area of La Caleta and is surrounded by a set of rocky lows, very dangerous for navigation. Another area of great difficulty for navigation is Punta del Nao, which has yielded many archaeological finds. It is located on the beach of La Caleta, west of the castle of Santa Catalina. Previously, this rocky reef has been known as Peña de Harnao and Punta de Arnao, later on, as Punta de Arnau.

The second major area of archaeological importance in the area of Cadiz is located on the island of Sancti Petri, a most interesting site that includes the wrecked remains of *Camposoto* and of *Fougueaux*, a French ship that fought in the Battle of Trafalgar (Fernández-Montblanc et al. 2018). In Punta Candor, several iron cannons

[9] Decreto 285/2009, BOJA. Download PDF: http://www.juntadeandalucia.es/boja/2009/129/d33.pdf

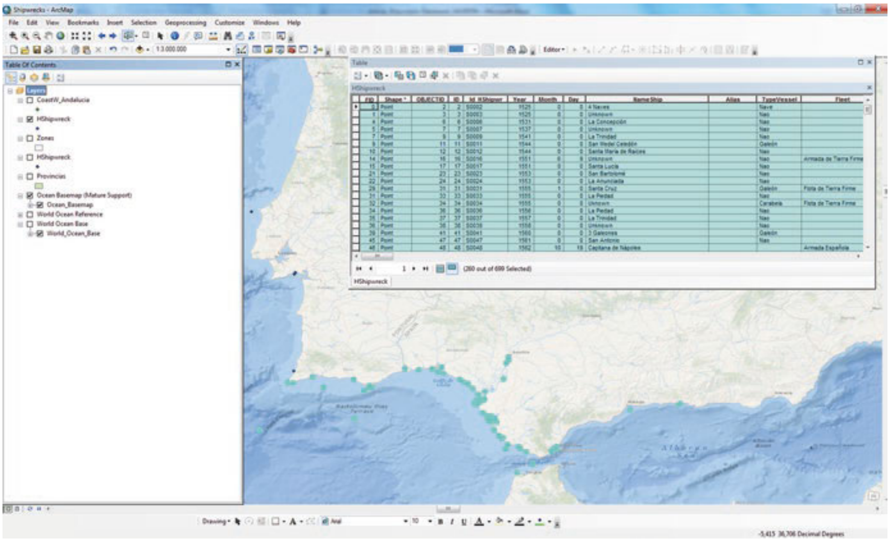

Fig. 13.4 View of "Shipwrecks" layer of South of Spain and Portugal Coasts

were located, and in 1992, an emergency operation removed two of them. There are also references to bronze artillery and documents of shipwrecks in this area. In front of the coast of Zahara may be the remains of *Santa Cruz*, and on the beaches of Conil, the *VeraCruz* and *San Juan Bautista*, close to Chiclana *San Francisco*, and *El Santísima Trinidad*, the flagship of the Spanish Navy in the seventeenth century, off the coast of Barbate. A long list of up to 1000 ships wrecked here between the fifteenth and seventeenth centuries, according to historians at the University of Cadiz. One of the six archaeological sites delimited in the province of Malaga is the wreck of *Los Santos*, near the coast of Benalmádena, which containing elements such as columns, marble slabs, and several statues of classical design. Regarding the four sites protected in Almería, the most important is Los Escullos-*El Águila*, where the remains of a Navy frigate of Felipe V is located in the vicinity of Embarcadero Cove; the ship, *El Águila*, wrecked in 1745. The two important sites in the province of Granada are Cerro Gordo and Punta de la Mona-Cueva del Jarro, on the coast of Almuñécar.

We have analyzed the *"Shipwrecks"* layer and have selected the South of Spain (Andalucia region) and Algarve Coasts, in the table associated with the zones of Huelva, Sanlúcar, and Sevilla around the Guadalquivir River, Cadiz, Gibraltar Coasts, Málaga, and Granada. This analysis resulted in 264 registers that correspond with the regions mentioned (Fig. 13.4). The map is represented with the following results: Huelva (20 registers), Sanlúcar (102 registers), the Coast of Cádiz (94 shipwrecks), and Tarifa and Gibraltar zone (5 registers), Málaga (4 registers), Granada (11 registers), and Portugal Coast (28 registers).

7.1 Mapping Historical Shipwrecks

We have created a map that represents the global *Shipwreck database* (Fig. 13.5), and we have represented several maps divided into study zones given the increased occurrence of Iberian shipwrecks. Since the beginning of the first fleets, regions of greater losses of ships were in the Caribbean Gulf, mostly due to hurricanes, from Veracruz and Matanzas to Bermuda and Florida (Fig. 13.6), while in the Iberian Peninsula (Fig. 13.7), it was the Bay of Cadiz that registered a high percentage of losses due to attempting to scale the Bar of Sanlúcar episodes or ships sunk in acts of war (Fig. 13.8). Another important region in Spain is the Galician-Asturian coast, one of the areas with the largest number of shipwrecks recorded (Fig. 13.9). According to the data collected in the Nautical Archaeology Digital Library (NADL) at least 57 wrecks have been localized and studied in Central American coasts and the Caribbean. The data can be double checked with the Historical Shipwrecks of the ForSEAdiscovery database as it has collected more than 600 locations.

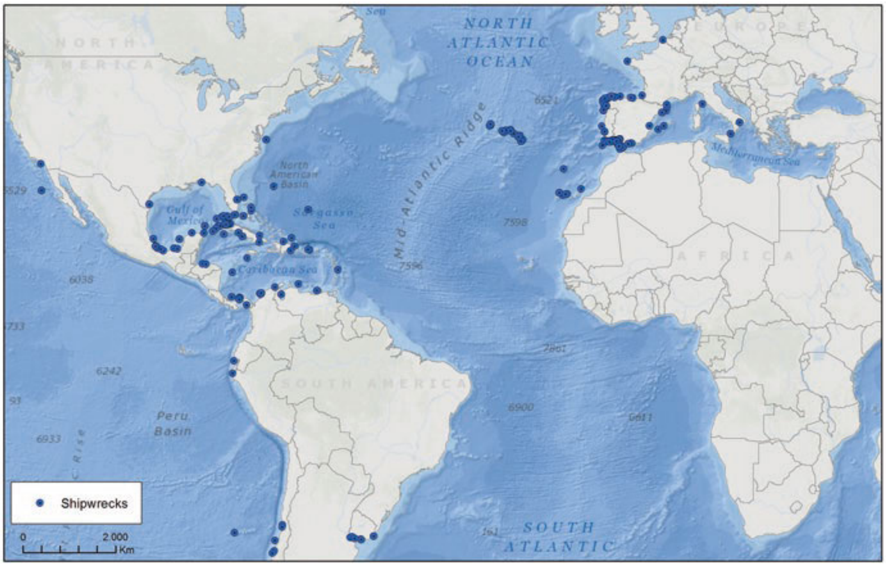

Fig. 13.5 Global Map of Iberian Shipwrecks (Source: Shipwreck database, Project ForSEAdiscovery. Service layer credits: Esri, Delome, GEBCO, NOAA, NGDC, and other contributors. Created by María José García-Rodriguez, Junio 2016)

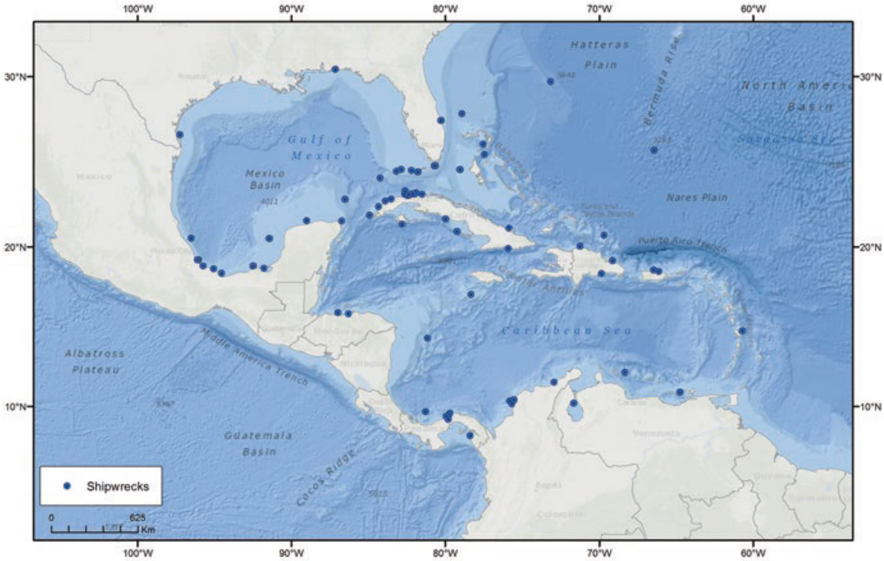

Fig. 13.6 Density of Iberian shipwrecks of Caribbean Sea and Gulf of Mexico, mostly due to hurricanes, from Veracruz and Matanzas to Bermuda. *(Source: Shipwreck database, Project ForSEAdiscovery. Service layer credits: Esri, Delome, GEBCO, NOAA, NGDC, and other contributors. Created by María José García-Rodriguez, Junio 2016)*

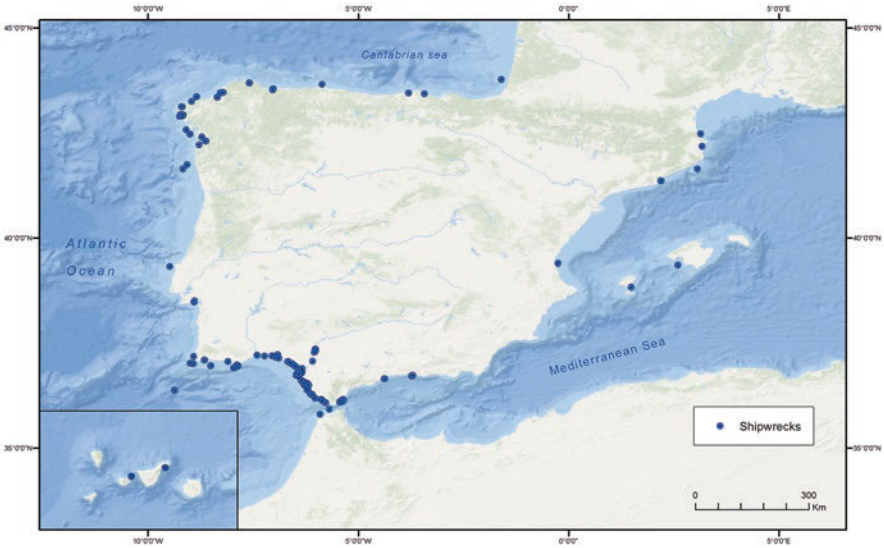

Fig. 13.7 Density of Iberian Shipwrecks in Spanish Coast. (Source: Shipwreck database, Project ForSEAdiscovery. Service layer credits: Esri, Delome, GEBCO, NOAA, NGDC, and other contributors. Created by María José García-Rodriguez, Junio 2016)

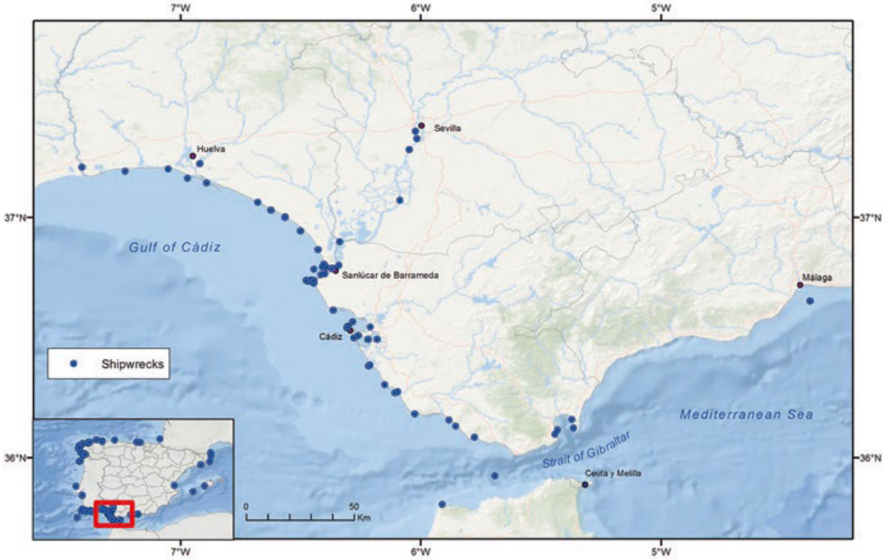

Fig. 13.8 Density of Iberian shipwrecks in South Coast of Spain (Gulf of Cádiz, Sanlúcar, Strait of Gibraltar, and Mediterranean Sea). (Source: Shipwreck database, Project ForSEAdiscovery. Service layer credits: Esri, Delome, GEBCO, NOAA, NGDC, and other contributors. Created by María José García-Rodriguez, Junio 2016)

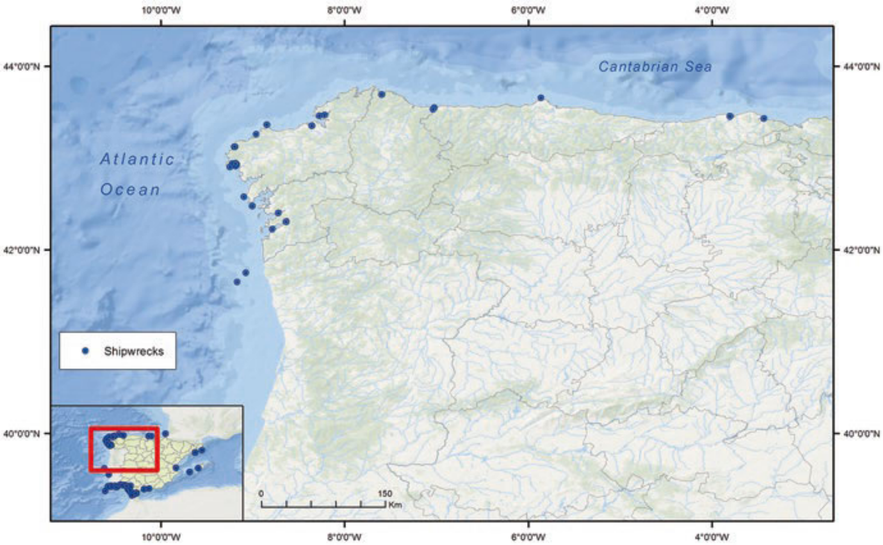

Fig. 13.9 Density of shipwrecks in Galician-Asturias Coast. (Source: Shipwreck database, Project ForSEAdiscovery. Service layer credits: Esri, Delome, GEBCO, NOAA, NGDC, and other contributors. Created by María José García-Rodriguez, Junio 2016)

8 Databases, GIS, and Internet

Geospatial technologies such as GIS allow users to link geographical space with historical events and to move beyond static mapping to represent the dynamism of historical events. In effect, it allows users to move from passive systems to interactive systems and to include better visualization, exploratory data analysis, and virtual reality. GIS and Internet systems convert diverse data into easy to read and easy to access maps and information. In addition, the advantages of the World Wide Web are numerous, the two primary ones being time independence and spatial independence. Distributing data over the Internet is more efficient than transmitting data through disks. Both Internet and GIS changed the processes of accessing, sharing, disseminating, and analyzing data. Technology to share GIS data, such as Web GIS, Open GIS, and Distributed GIS on the Internet is progressing quickly.

Web-based GIS includes any application that uses Internet technology to make geographic data available. Geographic information can be distributed in a variety of forms on the Internet. Maps may be static with a predesigned symbology or dynamic where the map itself is interactive, such as with a zoom in/out feature for homing in on a region of particular interest. Simple searches are also performed in a database according to a set of criteria. These criteria can be either spatial or thematic. The records that match the criteria are then returned to the user, either in a map or text report format. In another type of distribution, users can perform complex multi-theme queries, create buffers and customized maps, and perform statistical spatial analysis. This way, users can create new data sets without altering the original data. For designing web-based GIS applications, a variety of programs and forms are available, but the web applications are based on the same client/server model. The client makes a request to a server, and the server processes the request and returns the information to the client. In this model, the process is shared between the client and the server.

As the final step, we have to integrate all databases (shipwrecks, archaeological sites, dendro-archaeology) of the ForSEAdiscovery project, so we are developing a Web-based GIS, with the functionality of a Web Map Server (WMS),[10] which defines a simple interface for web-based mapping applications. Meanwhile, the Iberian Shipwrecks and Voyages Database has been used for the development of a web application, which has been created under the SILK platform (open source and free software). It is used to explore data, visualize graphs or maps, and share information. The Web Page (http://shipwrecks-early-modern-age.silk.co/) features two search engines, one for Iberian voyages during the sixteenth to seventeenth centuries and the other for shipwrecks. The shipwreck database can be visualized in tables or lists according to the fields of interest (Year, Name ship, Fleet, General Captain, Captain, Convoy, Incidence, Deaths Number, Place, Route). We can

[10] The WMS protocol is based on a simple query syntax for posting a request for the desired layers and zoom window to the server, which returns a map as a standard picture (GIF, PNG or other format).

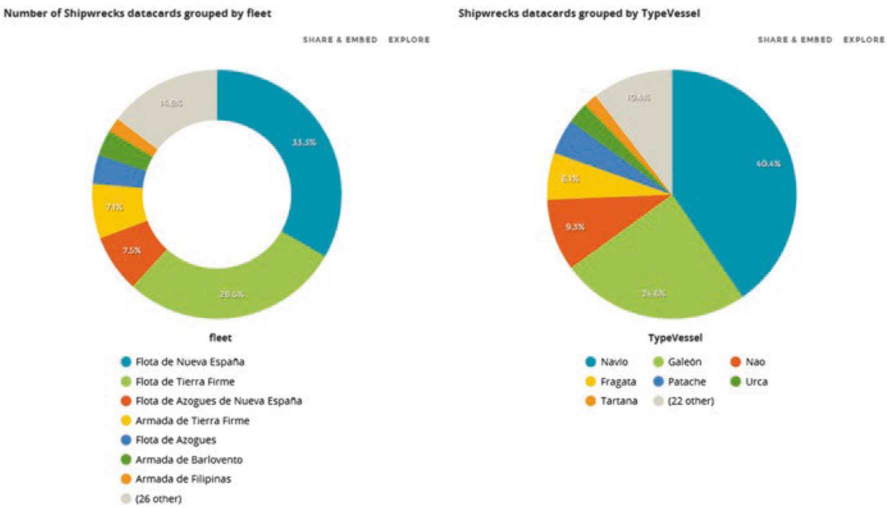

Fig. 13.10 Graphs show data grouped by the fleets and type of vessel with major shipwrecks that occurred in Indies Trade (in percent). Web page created with SILK: (http://shipwrecks-early-modern-age.silk.co/)

explore the data one to one, or by making a selection from a geospatial data source according to query constraints, such as a search area or certain field. Also, we can create web pages that allow navigation through the data and display interactive charts and maps (Fig. 13.10).

9 Discussion and Conclusions

Many hundreds of shipwrecks are listed in established geodatabases (698 registers), some of which are very well known and others that are unknown to the general public. But in many cases, the detail recorded is sufficient for research or management purposes of an underwater archaeology project. Ships were the result of a number of factors, many of which were dependent on the ever-changing social, economic, and political landscape. The most important thing about ships is undoubtedly the people that ordered, thought about, planned, and executed their construction. Their final shape, size, and performance depended on the availability of materials, tools, knowledge, and personal skills, which may have been combined with fashions and perceptions of a reality that is unknown to us now. To locate possible wreck sites, information about maritime trade routes, international conflicts, ship types, and ship loss records were studied through primary and secondary sources.

The shipwrecks database of the ForSEAdiscovery project will provide information about little known periods or aspects of our shared past. The database is important because these shipwreck sites are often under threat and because they can provide information to satisfy a collective quest for understanding the past. The shipwrecks database includes a relevant bibliography and provides astounding information on the impact of the Indies trade, which should be studied and continually updated to reflect new discoveries made through historical, archaeological, art historical, and scientific research.

This effort is an important contribution to the history of science and technology, having assembled information on shipwrecks and maritime incidents over three centuries in a geodatabase. This geodatabase, which is implemented in a GIS, is accessible to users, who can easily perform queries and data analyses and visualize or represent the results on maps or graphics. The GIS application is easy to use and it provides a valuable resource for accessing spatial datasets. On the client side of the application, only a web browser and network access is needed.

Moreover, this database is being integrated with other databases produced by ForSEAdiscovery. One such database has collected relevant archaeological data developed by Filipe Castro (Borrero et al. 2021).[11] This collection is necessary because, despite plenty of information, it is difficult to find connections between the archaeological sites located thus far. For instance, in areas such as in the Gulf of Mexico, without connections between the ship remains, it is difficult to date them and match them with historical records. This work attempts to create an analysis model to solve this problem based on the study of timber located on the excavation sites. Through establishing the date of a ship's construction, dendrochronology helps to connect history and archaeology. The data produced by all three sciences can be integrated into a GIS, which houses information on the location and date of the wreck, the construction date of the ship, and geographical origins of the timber from which the ship was constructed, as well as all other relevant information gathered about the vessel.

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[11] See also: Crespo Solana, A. & Castro, F., *The ForSEAdiscovery Database. The Origin* https://www.academia.edu/20167289/The_ForSEAdiscovery_Database._The_origin, Octubre 2015).

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Correction to: Heritage and the Sea: Volume 1

Ana Crespo Solana, Filipe Castro, and Nigel Nayling

Correction to:
A. Crespo Solana et al. (eds.), *Heritage and the Sea*,
https://doi.org/10.1007/978-3-030-86460-6

Chapter 1

The original version of this chapter was published without including the editor's final changes. These changes have now been included, and the book has been updated with the change.

Chapter 2

The original version of this chapter was published without including the editor's final changes. These changes have now been included, and the book has been updated with the change.

Chapter 4

The original version of this chapter was published without updating the affiliation for one of the authors "Marijo Gauthier-Bérubé". The affiliation has now been updated in the chapter and front matter (contributors), and the book has been updated with the change.

The updated version of these chapters can be found at
https://doi.org/10.1007/978-3-030-86460-6_1
https://doi.org/10.1007/978-3-030-86460-6_2
https://doi.org/10.1007/978-3-030-86460-6_4
https://doi.org/10.1007/978-3-030-86460-6_12
https://doi.org/10.1007/978-3-030-86460-6_13
https://doi.org/10.1007/978-3-030-86460-6

A. Crespo Solana et al. (eds.), *Heritage and the Sea*,
https://doi.org/10.1007/978-3-030-86460-6_14

Chapter 12

The original version of this chapter was published without including the editor's final changes. These changes have now been included, and the book has been updated with the change.

Chapter 13

The original version of this chapter was published without updating the affiliation for one of the authors "María José García-Rodríguez". The affiliation has now been updated in the chapter and front matter (contributors), and the book has been updated with the change.

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A. Crespo Solana et al. (eds.), *Heritage and the Sea*,
https://doi.org/10.1007/978-3-030-86460-6