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In Search of Unique Iberian Ship Design Concepts

ABSTRACT

Defining 15th- and 16th-century Iberian shipbuilding traditions related to European expansion overseas is a difficult task. Scarce documentary evidence and the systematic destruction of Spanish and Portuguese shipwrecks by those with a purely monetary agenda make the task even more complex. In spite of these obstacles, data suggests that a distinctive shipbuilding tradition existed on the Iberian Peninsula. Through careful mining of the documentary and archaeological evidence, the concepts behind Iberian ship design can be articulated as well as compared and contrasted to other European shipbuilding traditions.

Introduction

The study of nautical archaeology is only a half-century old. Although a sizeable overall sample of shipwrecks has been studied around the world, there is no one type with a sample large enough to approximate the principle of redundancy practiced in terrestrial archaeology. From an history of technology perspective, synthesis of broad interpretive schemes and conceptual modalities is not possible from shipwreck data alone. Furthermore, ships are like fingerprints: they share conceptual characteristics, but each differs slightly, producing a unique construction set with distinctive sailing and handling qualities. There is only one *Kyrenia* and there is only one *HMS Victory*, but if either of these ships were compared to a number of contemporary examples, the shared conceptual designs and features of their individual cultures would be obvious. It is important to first examine the wider context of the European history of shipbuilding and its influence on Iberian shipbuilding. To do this, historical documents regarding the economical, political, and social contexts in which ship designs were conceived, built, and operated must be consulted, along with iconographic and ethnographic materials. This is an arduous task since documentary evidence, both textual and iconographic, is dispersed, scarce, and often vague for the first 150 years of the Age of Exploration. Researchers know caravels sailed southwards along the western coast of Africa from the first quarter of the 15th century, and yet no treatise on shipbuilding exists until the 1570s (Domingues 2005:13). Ethnographic data are scarce and relate largely to a different type of working craft, smaller, built by eye in coastal settlements for their population's everyday work, as opposed to the ocean-going vessels produced during the state-driven shipbuilding revolution of the 15th and 16th centuries under analysis. The combined textual and ethnographic evidence suggests, nevertheless, that Iberian ship design and construction was strongly influenced by imported Italian shipwrights, following a conceptual model that is believed to originate in Mediterranean galley construction, although archaeological proof of this is inconclusive. Arab influence may also have been important, although it is even more difficult to prove because there is an almost complete lack of evidence.

Spanish scholars led the first scientific studies in Iberian naval archaeology in the late-19th century, during the decade that preceded the 400th anniversary of the Columbus voyages in 1892. This Spanish interest in the "Ships of Discovery" triggered research and studies in Portugal. In the century that followed, scholars from both countries produced a series of thorough studies that entailed a meticulous combing of the archives, in both countries and abroad (Domingues 2000:13–56). These works are historical in nature since the scientific study of shipwrecks had not yet begun. Moreover, human carelessness and Mother Nature had already reduced the reservoir of documentary evidence through fires, natural decay, earthquakes, and tidal waves. Yet, 19th-century scholars diligently studied and analyzed what remained, including the existing iconography. Although a systematic analysis of the surviving iconography still awaits comprehensive study, the majority of the existing iconography from the 15th and 16th centuries is published (Barata 1989:15–102; Casado Soto 2001:131–161). Now, little more than a century since the first scholarly studies of the

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Iberian ship designs were published, it is fair to state that further understanding of Iberian shipbuilding of the period under analysis rests almost exclusively on the study of ship archaeological remains (Alves 2001).

Given the rate of systematic destruction of Spanish and Portuguese shipwrecks for economic gain, without giving thought to the knowledge carried within the remnant ship structure, the odds are not in favor of nautical archaeology. Historical archaeologists need to evaluate and organize the information available and use future finds to compare, contrast, and fill in the gaps in knowledge about these amazing artifacts, perhaps the most expensive and sophisticated ships that were built in their time. This paper looks at what is known, archaeologically and through historical documentation, and sets the groundwork for comparison in the hopes that the study of Iberian ship design will reach the enviable status of redundancy in the future.

Beginning with archaeologically recovered data, all Iberian shipwrecks that have been found and of which some information has been somehow published are listed in tables 1 through 5. Table 6 shows the hull remains that have been found bearing characteristics that are commonly associated with Iberian construction but that are known or at least suspected to have been built elsewhere. Although detailed recording and technical descriptions of each ship's construction characteristics admittedly do not make very exciting reading, this information is of paramount importance for future comparative studies. Despite the fact that these ships made possible European exploration and expansion overseas during the 15th and 16th centuries and were arguably the equivalent to today's space shuttles, scholarly monographs often reduce ships to dry and uninspiring sets of tables and numbers, geometrical algorithms, and timber assemblage arrangements.

Ships resulted from a number of factors, many of which were contingent upon 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. The study of the ideas and the people behind the revolution in ship design, which made possible the discovery of new continents and the exploration of new seas, islands, and continents, is important and exciting. Such study will certainly make a relevant contribution to the history of science and technology. Articles about ship design can and sometimes do make captivating reading. One can only hope that when more scholars produce exciting papers, acknowledging the people behind the artifacts, the value of shipwreck remains will exceed the economic gain associated with salvage in the minds of journalists, politicians, antique dealers, and the public.

Research Questions and Parameters

To fully address ship design concepts, it is relevant to ask a series of questions. Is there a set of unique artifactual components or characteristics that can be identified in the archaeological remains of a ship, marking it as Iberian? How different is Iberian shipbuilding from other contemporary shipbuilding traditions? Was there an Iberian shipbuilding tradition during the Age of Exploration (15th–17th centuries) or is this just a cultural myth?

All of these questions must be couched in the parameters of the time. First, there were no international standards for shipbuilding and there were no national standards until the beginning of the 17th century. Second, shipbuilding was an art based on oral tradition and learned through apprenticeship (Dell'Amico 2002:21–25). Third, since there were only vague unit standards and the concept of precision was much different, it is difficult to look for standard measurements or precise proportional relations among ships' parts.

Not even the advent of the printing press transformed shipbuilding from tradition to replicable science until much later. Although the earliest treatises often aimed at codifying cultural concepts, these were not printed and did not circulate outside very small and generally national circles of interested people. Most shipbuilding treatises remained in manuscript forms, although a Spanish merchant authored the first printed naval architectural treatise and lawyer named Diego García de Palacio and was printed in Mexico in 1587.

TABLE 1
NEW WORLD ROUTES: SIXTEENTH-CENTURY SHIPWRECKS

Shipwreck	Date	Location	Timber remains	Data[1]
Molasses Reef Shipwreck	Early-16th century	Bahamas	Small portion	Salvaged/Excavated (1)
Highborn Cay Shipwreck	Early-16th century	Bahamas	Part of the bottom	Salvaged/Excavated (1)
Bahia Mujeres Shipwreck	Early-16th century	Mexico	None	Surveyed (1)
Playa Damas Shipwreck	Early-16th century	Panama	Part of the bottom	Surveyed/Salvaged (2)
San Esteban	1554	Texas	Stern heel	Salvaged/Excavated (1)
Espiritu Santo	1554	Texas	Unknown	Salvaged (1)
Santa Maria de Yciar	1554	Texas	Unknown	Destroyed by dredges (1)
La Condesa	1555	Portugal	Unknown	Looted? (3)
Emanuel Point Shipwreck	1559	Florida	Extensive	Partially excavated (1)
Saint John's Bahamas Shipwreck	Mid-16th century	Bahamas	Part of upper works	Excavated (1)
Mystery Wreck of MAREX	Mid-16th century	Bahamas	Unknown	Salvaged (1)
Caio Nuevo Shipwreck	Mid-16th century	Mexico	None	Surveyed (1)
Francisco Padre	Mid-16th century?	Cuba	Unknown	Salvaged? (4)
Galera	Mid-16th century?	Cuba	Unknown	Surveyed (5)
San Juan	1565	Canada	Extensive	Excavated (1)
San Pedro	1596	Bermuda	Unknown	Salvaged (1)
Western Ledge Reef Shipwreck	Late-16th century	Bermuda	Extensive	Excavated (1)
Spanish Wreck	Late-16th century	Bermuda	Yes	Salvaged (1)
Ines de Soto Shipwreck	Late-16th century	Cuba	None	Excavated (1)
San Cayetano	Late-16th century?	Cuba	Unknown	Excavated (5)
Basque galleon 1	16th century	Canada	Yes	Surveyed (6)
Basque galleon 2	16th century	Canada	Yes	Surveyed (6)
Basque galleon 3	16th century	Canada	Yes	Surveyed (6)
Saona Site 1	16th century	Dominican Republic	Unknown	Salvaged/Surveyed (7)
Saona Site 2	16th century	Dominican Republic	Unknown	Salvaged/Surveyed (7)
Saona Site 3	16th century	Dominican Republic	Unknown	Salvaged/Surveyed (7)
West Turtle Shoal	16th century?	Florida	Part of the stern	Salvaged/Surveyed (8)
Angra B	16th century	Azores	Part of the bottom	Surveyed (1)
Angra D	16th century?	Azores	Extensive	Excavated (1)

[1] Data sources: (1) Castro 2005b:193–202; (2) Castro 2005c; (3) Toja 1990; (4) Alejandro Mirabal <http://arq.de/downloads/curriculos/eng_alejandro_mirabal.pdf> on 20. Oct. 2005; (5) López Pérez and Díaz Pelegrín 2005; (6) Robert Grenier 2003, pers. comm. ; (7) Turner 1994; (8) Roger Smith 2005, pers. comm.

TABLE 2
NEW WORLD ROUTES: SEVENTEENTH-CENTURY SHIPWRECKS

Shipwreck	Date	Location	Timber remains	Data[1]
Fuxa Shipwreck	Early-17th century	Cuba	Extensive	Excavated (1)
Green Cabin Shipwreck (*San Martin*)	1618	Florida	Part of the bottom	Surveyed (1)
San Antonio	1621	Bermuda	Unknown	Salvaged (1)
Nuestra Señora de Atocha	1622	Florida	Part of the bottom	Salvaged/Partially recorded (1)
Shot Wreck	1622	Florida	Unknown	Salvaged (1)
Santa Margarita	1622	Florida	Part of upper works	Salvaged/Partially recorded (1)
Dry Tortugas Shipwreck	1622	Florida	Extensive	Salvaged (1)
Nuestra Señora del Rosario	1622	Florida	None	Surveyed (1)
Urca La Viga	1639	Bermuda		Salvaged (1)
Nuestra Señora de la Concepción	1641	Dominican Republic	Unknown	Salvaged (1)
Stonewall Shipwreck	Mid-17th century	Bermuda	Part of the bottom	Salvaged/Surveyed (1)
Nuestra Señora de las Maravillas	1656	Bahamas	Unknown	Salvaged (1)
Jesús M.ª de la Limpia Concepción	1654	Ecuador	Unknown	Salvaged (1)
Santíssimo Sacramento B	1668	Brazil	Extensive	Excavated (1)
San Francisco Wreck	1650–1660	Cape Verde	Unknown	Salvaged (9)
Los Lingotes	Late-17th century?	Cuba	Unknown	Surveyed (5)

[1] Data sources: (1) Castro 2005b:193–202; (5) López Pérez and Díaz Pelegrín 2005; (9) From <http://www.arq.de/english/sanfrancisco.htm> accessed 20 Oct. 2005.

TABLE 3
MANILA GALLEONS: SIXTEENTH- AND SEVENTEENTH-CENTURY SHIPWRECKS

Shipwreck	Date	Location	Timber remains	Data[1]
San Felipe	1575	Baja California	None	Surveyed (10)
San Diego	1600	Philippines	Extensive	Salvaged/Partially recorded (1)
Nuestra Señora de la Concepción	1638	Guam	Unknown	Salvaged (1)
Santa Margarita	17th century?	Guam	Unknown	Salvaged (1)
Nuestra Señora del Pilar	1690	Guam	Unknown	Salvaged? (11)

[1] Data Sources: (1) Castro 2005b:193–202; (10) Edward van der Porten 2003, pers. comm.; (11) From <http://www.maritimeinvestment.com.au/pilar.html> accessed 20 Oct. 2005.

TABLE 4
EUROPE: SIXTEENTH- AND SEVENTEENTH-CENTURY SHIPWRECKS

Shipwreck	Date	Location	Timber remains	Data[1]
Corpo Santo	Late-14th century	Portugal	Stern heel	Excavated (1)
Ria de Aveiro A	Mid-15th century	Portugal	Part of the stern	Excavated (1)
Cais do Sodré	Late-15th century?	Portugal	Extensive	Excavated (1)
Studland Bay	Early-16th century	England	Unknown	Excavated (1)
Baleal 1	16th century	Portugal	Unknown	Looted (12)
Arade 1	Late-16th century	Portugal	Extensive	Excavated (13)
Santa Maria de la Rosa	1588	Ireland	Part of the bottom	Excavated (1)
Capitana de Ivella	1596	Spain	None	Surveyed (1)
Ponta do Altar B	Early-17th century	Portugal	None	Surveyed (1)

[1] Data sources: (1) Castro 2005b:193–202; (12) Castro 2004; (13) Castro 2005a.

Shipbuilding treatises began appearing in the Iberian Peninsula in the final quarter of the 16th century but were not written *by* shipwrights and do not seem to have been written *for* shipwrights. They seem, rather, to be a consequence of a Renaissance taste for collecting and organizing knowledge, and eventually using it in enlightened discussions of learned men. Neither the Spanish nor the Portuguese texts contradict the idea of a typical, unique Iberian oceangoing merchantman type, but these texts are far from codifying such ships. The texts seem to aim at a standard vessel for the Portuguese India route, the *nau* with a capacity of 500 to 600 tons and echo a known state trend to standardize and organize its affairs. It is relevant that in some ways the standardization of shipbuilding in written treatises worked against the concept of unique, cultural shipbuilding designs and accelerated the concept of a universal design, undistinguishable by cultural characteristics. If there was a unique Iberian shipbuilding concept, the later years of the Age of Exploration mark the beginning of its terminus.

Iconographically, ships were loosely captured, prior to the rise of the Dutch middle class, in architectural motifs and the rare model. Although ships were ubiquitous, it was not until the rise of the merchant class that portraits of ships were commissioned regularly. The genre of marine art can be traced to the Netherlands where Dutch artists began capturing ships of the merchant class on canvas. In keeping with other contemporary genres of Dutch art, marine art was extremely accurate, often the work of painters who had gone to sea during their careers (Taylor 2004). This art form followed the rise of the merchant class throughout Europe and England. In the late-16th century, the work of Hendrick Cornelisz. Vroom (ca. 1566–1640) gained some admiration in Spain but did not seem to have established a school of maritime painting. A few of his paintings seem to have been purchased in Portugal during his stay (on the way to Holland, from Italy, after a shipwreck), but there is no serious marine art in Portugal until much later (Russell 1983:3).

European shipbuilding raced to keep up with the changing geopolitical landscape of the 16th century. It was a dynamic time, and ship types and ship construction changed rapidly along with all other facets of European cultures. Fernando Oliveira, a Portuguese priest who wrote some of the best ship treatises of his time, noted that "less than forty years ago the names *zabra* and *lancha* were not known on this land [Portugal] and now they are common." After explaining further how some boat names were recently introduced and others completely forgotten, he continued: "The boats from Santarém [a village

TABLE 5
PORTUGUESE INDIA ROUTE: SIXTEENTH- AND SEVENTEENTH-CENTURY SHIPWRECKS

Shipwreck	Date	Location	Timber remains	Data[1]
Portuguese Shipwreck	Early-16th century	Mayotte	Unknown	Looted (14)
Portuguese Shipwreck	Early-16th century	Madagascar	None	Surveyed (24)
S. João	1552	South Africa	Unknown	Surveyed (1)
S. Bento	1554	South Africa	Unknown	Surveyed (1)
Fort San Sebastian Shipwreck	Mid-16th century?	Mozambique	Extensive	Salvaged (15)
Santiago	1585	Bassas da India Atoll	Unknown	Salvaged (1)
Sto. António	1589	Seychelles	Small portion	Looted/Surveyed (1)
Sto. Alberto	1593	South Africa	Unknown	Surveyed (1)
Cochin Shipwreck	Late-16th century	India	Unknown	Looted? (14)
Wan-Li Shipwreck	Early-17th century	Malaysia	Unknown	Salvaged (15)
Nossa Senhora dos Mártires	1606	Portugal	Small portion of the bottom	Looted/Excavated (1)
Espiritu Santo	1608	South Africa	Unknown	Surveyed (1)
Madre de Deus	1610	Japan	Unknown	Destroyed by dredge works (16)
Nossa Senhora da Luz	1619	Azores	None	Surveyed (1)
S. João Baptista	1622	South Africa	Unknown	Surveyed (1)
Sao Joseph	1622	Mozambique	Unknown	Salvaged? (17)
S. Gonçalo	1630	South Africa	Unknown	Survivor's camp excavated (1)
Santa Maria Madre de Deus	1643	South Africa	Unknown	Surveyed (1)
Santíssimo Sacramento	1647	South Africa	None	Salvaged (1)
N.ª S.ª da Atalaia do Pinheiro	1647	South Africa	Unknown	Survivor's camp excavated (1)
Sunchi Shipwreck	Mid-17th century	India	None	Excavated (17)
Sto. António de Tana	1697	South Africa	Extensive	Excavated (18)

[1] Data sources: (1) Castro 2005b:193–202; (14) Patrick Lizé 2006, pers. comm.; (15) From <http://www.mingwrecks.com/wanli.html> accessed 20 Oct. 2005; (16) Reis 2002:81; (17) Tripati et al. 2006; (18) Piercy 1977, 1978, 1979, 1981; (24) A. Rosenfeld 2006, pers. comm.

located on the margins of the Tagus River, 70 km upstream from Lisbon] raise now their heads further, and change their names from *cervilhas* to *muletas*; and this is from four days ago to the present; imagine the change that will occur in one hundred, or two hundred years from now" (Oliveira 1580:76).

Maritime World of the Iberian Peninsula

Units of Measure

Beginning with the most basic pieces of information for comparison, it is immediately apparent that even the units of measure were

TABLE 6
EUROPE: SIXTEENTH- AND SEVENTEENTH-CENTURY IBERIAN-LIKE SHIPWRECKS

Shipwreck	Date	Location	Timber remains	Data[1]
Cattewater	Early-16th century	England	Extensive	Excavated (19)
Lomelina	1512	France	Extensive	Excavated (20)
Rye A	16th Century	England	Part of a mast step	Surveyed (21)
B&W 7	Late-16th century	Denmark	Part of the bottom	Excavated (23)
Calvi	Late-16th century	France	Extensive	Excavated (22)
Saint Honorat I	17th century	France	Unknown	Surveyed (1)

[1] Data sources: (1) Castro 2005b:193–202; (19) Redknap 1984; (20) Guérout et al. 1989; (21) Lovegrove 1964; (22) Villié 1989, 1990, 1991; (23) Lemée 2006.

not consistent throughout the Iberian Peninsula. Spanish shipwrights used one of two *codos* (or cubits), measuring approximately 55.7 cm in Andalusia (*codo castellano*) and 57.5 cm in the Basque country (*codo cantábrico*). This Basque *codo* was eventually adopted for the whole country after 1590 (Casado Soto 1988:102–104). Portuguese counterparts used the *rumo*, thought to be Genoese in origin and equivalent to 154 cm, the height of a Portuguese *tonel*. These values were broken down into *palmos and dedos* (Table 7). The Portuguese *tonel* was also a unit of volume, measuring 1.275m^3. A Spanish *tonel* was 20% larger measuring 1.521 m^3. One Spanish *tonel* equaled 8 cubic *codos cantábricos*. Considering that both units of volume were used, the Iberian *tonelada* of burden ranged between 1.7 and 2.2 modern metric tons of displacement (Castro 2005b:189–192).

TABLE 7
SPANISH AND PORTUGUESE SHIPBUILDING UNITS IN THE SIXTEENTH CENTURY

Unit	Metric System Equivalent	Country
Codo castellano	55.7 cm	Spain
Codo cantábrico	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

Sources: Casado Soto 1988; Castro 2005.

Ship sizes

Early in the 17th century the Habsburg kings, who ruled both the crowns of Spain and Portugal between 1580 and 1640, issued legislation to standardize the construction of oceangoing ships (Serrano Mangas 1985; Vicente Maroto 1998). It is not clear how effectively these rules were enforced, but it is a fact that commissions of experts from both Spain and Portugal seriously discussed the size and shape of Iberian ships and that there was a convergence on ship design and construction throughout Europe during this century (Barcelos 1899). Following the development of the firearm, which helped centralize power, Gutenberg's invention of the printing press in the 15th century slowly transformed all of Europe. By 1570 the appearance of a number of texts and treatises on shipbuilding documented the variety of typical oceangoing vessel for each major route (Table 8). Again, these texts suggest that there were several common traits to Spanish and Portuguese (Iberian) oceangoing ships.

The descriptions of *naos*, caravels, and galleons are similar for both geopolitical sovereignties. Sizes vary within each type but cluster around several functional standard sizes, which are in turn closely aligned to a particular route or function within the fleets.

Small Coasting Craft Designs vs. Oceangoing Ship Designs

Small Craft

Throughout history, shipbuilders conceived, designed, and constructed vessels for diverse purposes, using available resources, traditional knowledge, and cultural exchange. Under the broad aegis of maritime trade and warfare, vessels of many different sizes and shapes were built for many different purposes. Not all ves-

TABLE 8
SPANISH AND PORTUGUESE TEXTS ON SHIPBUILDING IN THE LATE-SIXTEENTH AND EARLY-SEVENTEENTH CENTURIES

Date	Author and Title	Bibliography
ca. 1570	Fernando Oliveira, *Ars nautica*	Ms. Voss. LAT. F. 41, Leiden University Library, Leiden, Netherlands. Unpublished.
1575	Juan Escalante de Mendoza, *Ytinerario de navegación de los mares y tierras occidentales*	Codice in Sec. Ms., Biblioteca Nacional, Madrid, Spain. Reproduced in facsimile in a CD Rom edition by the Fundación Histórica Tavera. Published in Cesáreo Fernández Duro, *Disquisiciones nauticas* (1880), 5 Vols., by Instituto de Historia y Cultura Naval, Madrid, Spain,1996, vol. 5, pp. 413–515.
ca. 1575–1625	Anonymous, *Livro náutico* e o *memorial das várias coisas importantes*	Ms. F.464; F. 889; F. 7241, Biblioteca Nacional, Lisbon, Portugal. Published in Francisco Contente Domingues, *Os navios do mar oceano* by Centro de História dos Descobrimentos, Lisbon, Portugal, 2005.
ca. 1580	Fernando Oliveira, *Livro da fabrica das naus*	Ms. 3702, Biblioteca Nacional, Lisbon, Portugal. Published as *O Livro da fabrica das naos.* Facsimile, transcription, and English translation by Academia de Marinha, Lisbon, Portugal, 1991. *O Liuro da fabrica das naos.* Facsimile, transcription and translations into English and Chinese, Macau by Museu Marítimo de Macau, 1995.
1587	Diego García de Palacio, *Instrucción nauthica para el buen uso y regimiento de las naos, su traza y govierno*,	Palacio, Diego García de, *Instrucción nauthica para el buen uso y regimiento de las naos, su traza y govierno*, Pedro de Ocharte, Mexico,1587. Reproduced in facsimile in a CD Rom edition by the Fundación Histórica Tavera. Partially reproduced in Cesário Fernandez Duro, *Disquisiciones nauticas* (1880), 5 vols., by Instituto de Historia y Cultura Naval, Madrid, Spain, 1996, vol. 5, pp. 5–36. Available in English translation by J. Bankston, Terrence Association, Bisbee, AZ, 1988.
1607	*Ordenanzas*	Ms. ? Reproduced in Martín Fernandez de Navarrete, *Colecçión de documentos y manuscriptos compilados por Fernandez de Navarrete* by Kraus Thomson Organization Ldt., Nendeld, Liechtenstein, 1971, vol. 23, pp. 575–592.

TABLE 8 (CONTINUED)
SPANISH AND PORTUGUESE TEXTS ON SHIPBUILDING
IN THE LATE-SIXTEENTH AND EARLY-SEVENTEENTH CENTURIES

Date	Author and Title	Bibliography
1607	*Ordenanzas*	Ms. ? Reproduced in Martín Fernandez de Navarrete, *Colecção de documentos y manuscriptos compilados por Fernandez de Navarrete* by Kraus Thomson Organization Ldt., Nendeld, Liechtenstein, 1971, vol. 23, pp. 575–592.
ca. 1608–1610	João Baptista Lavanha, *Livro primeiro de arquitectura naval*	Cod. 63; Fls. 41-78, Col. Salazar, Library of the Real Academia de Historia, Madrid, Spain. Published as *Livro Primeiro de Architectura Naval*, Facsimile, transcription and English translation by the Academia de Marinha, Lisboa, Portugal, 1996.
1611	Tomé Cano *Arte para fabricar, fortificar y aparejar naos de guerra merchante*	Tomé Cano, *Arte para fabricar, fortificar y aparejar naos de guerra merchante.* Luis Estupiñan, Seville, Spain, 1611. Reproduced in Cesário Fernandez Duro, *Disquisiciones nauticas*, 5 Vols., (1880), by the Instituto de Historia y Cultura Naval, Madrid, Spain, 1996, vol. 5, pp. 36–97.
1613	*Ordenanzas*	Archivo General de Indias, Seville, Indiferente, 2595. Reproduced in Fernando Serrano Mangas, *Función y evolución del galeón en la carrera de Indias*, Madrid, Spain, 1992, pp. 211–239.
1616	Manoel Fernandez, *Livro de traças de carpintaria*	Cod. Manoel Fernandez, Biblioteca do Palácio Nacional da Ajuda, Lisbon, Portugal. Published as Manoel Fernandez, *Livro de traças de carpintaria,* 1616. Facsimile by the Academia de Marinha, Lisboa, Portugal, 1989; Transcription and translation into English by the Academia de Marinha, Lisboa, 1995.
ca. 1630	Gonçalo de Sousa, *Coriosidades de Gonçalo de Sousa*	Ms. 3074, Biblioteca Geral da Universidade de Coimbra, Coimbra, Portugal. Published as Francisco Contente Domingues, *Os navios do mar oceano*. Centro de História dos Descobrimentos, Lisbon, Portugal, 2005.
1618	*Ordenanzas*	*Recopilación de Leyes de los Reynos de las Indias* (1680), 3 vols. Edited in 1943 by Gráficas Ultra, Madrid, Spain. Reproduced in José Luis Rubio Serrano, *Arquitectura de las Naos y Galeones de las Flotas de Indias*, 2 Vols. Ediciones Seyer, Malaga, Spain, 1991.
1631–1632	Pedro Lopez de Soto (?), *Diálogo entre un vizcaíno y un montañés*	Ms. 2593, Library of the University of Salamanca, Salamanca, Spain. Published as Maria Isabel Vicente Maroto, *Diálogo entre un Vizcayno y un Montañéz sobre la Fábrica de Navíos*, Ediciones Universidad de Salamanca, Spain, 1998.
1640–1641	Marcos Cerveira de Aguilar, *Advertências de navegantes*	Cod. 13390, Biblioteca Nacional, Lisboa, Portugal. Unpublished.

sels were large or partook in transoceanic trade. Many performed smaller, humbler activities such as transporting people and animals; participating in general riverine traffic between the coast and hinterlands; plying coastal trade; facilitating fishing, piloting, and messenger service.

Designs of small craft were as diverse as the people who created them. Although the

Iberian Peninsula is not exceptionally large geographically, a minimum four different distinctive coastal regions can be identified: the Bay of Biscay westwards to Galicia; the Atlantic coast of Portugal; the Algarve and Andalusian coast (the old Western Arab coast); and, beyond Gibraltar, the Mediterranean coast, encompassing Catalonia and its formidable seafaring tradition. Visitors and invaders that established colonies and factories along the Iberian coastlines influenced each one of these indigenous populations. Phoenicians, Greeks, Carthaginians, Romans, Goths, and Arabs each left their marks in the architecture, language, agriculture, religious beliefs, and many other cultural and technological traits, including shipbuilding traditions. It is not surprising that Iberian craft have a particular look, reflecting many outside cultural influences.

In the 19th century, Admiral Quirino da Fonseca (1915) listed 167 different types of ships and boats mentioned in historical documents for Portugal alone—a sizeable variety of vessel types for a relative small geographic area. Modern research and ethnographical work confirm this diversity of solutions. Some boat types still exist, and their antecedents are traceable. For example, Galicia's *dornas* are lapstrakes, built with a clear northern influence (Romero 1991:107), while the bottom-based *barcos rabelos* from the Douro River in the north of Portugal were built with flush-laid bottoms and lapstrake sides like the medieval cogs (Filgueiras 1992). To the south, the *saveiros* from the city of Aveiro are evolved plank canoes, and they look very similar to a Middle Eastern model from the third millennium B.C. at Ur (Filgueiras 1980:11). On the other hand, the Mediterranean influence is clear along most of the southern part of the Portuguese coast. Algarve's *caíques* are a good example of the Mediterranean *lateeners* (Iria 1963).

Emergence of Three-Masted Ships

It is generally accepted that northern Europe and the Mediterranean were two different worlds, with different trading networks, organizations, and ship designs. Late-medieval maritime trade was carried in both galleys and round ships, which were frame-based, lateen-rigged, carrying one, two, or three masts. In contrast, the workhorses of the Baltic and North Atlantic trade were square-rigged, clinker-built vessels, sometimes referred to as keels, probably descending directly from the 11th-century short sea traders. A well-preserved archaeological example of these is the Skuldelev 1 boat, carrying approximately 25 tons (Crumlin-Pedersen and Olsen 2002:125).

From the 11th century onwards, as cities grew and the trade between them intensified, clinker-built boats like the Skuldelev 1 grew in size and became the hulks depicted on town seals and in historical sources (Crumlin-Pedersen 1991:76–79). Hulks were partially replaced, in the early-14th century, by another type of trading craft: the cog (Adams 2003:51–58). Cogs emerged sometime during the early-12th century and differed from hulks in that they were constructed from sawn planks, with a flat, flush-laid bottom and central rudder. Only the upper sides of the cog were lapstrake. Also rigged with square sails, cogs may have influenced the development of a new type of vessel in the Mediterranean, commonly referred to as *cocca* (*cocche, pl.*). This design may be the direct ancestor of the Italian *carracks*, the Spanish *naos*, and the Portuguese *naus*. *Cocche* had many characteristics of Mediterranean design, including integrated castles and flush-laid planks nailed to a pre-existing frame structure, but unlike other Mediterranean designs, *cocche* mounted a square sail like their northern relatives.

Around this time, at the beginning of the 14th century, the most common Mediterranean design was the nave, a two-masted round ship. This type was used continually from at least the 11th to the 20th centuries, when Portugal had small, two-masted lateeners, named *caíques,* engaged in short sea trade along the country's coast (Iria 1963). A good example of this design dating to the 11th century is *Serçe Limani*, a shipwrecked vessel excavated off the coast of Turkey (Matthews 2005:185). During the 14th century, these ships appear with a square sail on the foremast. As early as 1336 or 1338, *navi* appear in the iconography with a square sail on the foremast, and soon after, images of *cocche* appear with the same rigging (Bellabarba 1999:85). There must have been some practical advantages to this rigging configuration, because its use expanded during the century and eventually evolved into a full-rigged ship with the addition of a third mast before the foremast. A 1409 document from Barcelona is the first to illustrate a *cocca* with a third mast mounted on the forecastle, rigged with a square sail (Mott 1997:146).

Three-masted vessels obviously fulfilled a need, since they were adopted very quickly both in the Mediterranean and along the north-European coasts. The English ship *Grace Dieu*, lapstrake-built in 1418, may have mounted three masts (Friel 1993:7).

Most European nations, including Portugal and Spain, adopted the three-masted ship, built on a framed-first design, during the 15th century. The extension of the frame-based shipbuilding model in northern Europe is relatively well documented in the archaeological record (Adams 2003).

In Portugal and Spain the advent of the three-masted ship is not as well understood. Historical documents clearly indicate that the strategically located Iberian Peninsula was the nexus of two worlds, but how this played out in ship design is not clear. Oliveira wrote in his 1580 treatise on shipbuilding, *Livro da fabrica das naus*, that the vessels in which the Portuguese sailed down the coasts of Africa were not much different from the *trincados* (literally lapstrakes) of Galicia (Oliveira 1580:76; Barker 1992:435). These *barchas*, as they were called, are unknown today and may have been full clinkers such as the keels, bottom-based vessels such as the cogs, or some design in-between.

Oceangoing Ships

Regarding the design of larger oceangoing ships, the landscape was considerably different (Figure 1). Oceangoing ships were conceived, designed, and built during the period after firearms helped consolidate state power and the geopolitical boundaries of the modern state. The monarchs that ordered these ships may have entertained a loose sense of their country's geographical boundaries, perceiving a rather fluid sense of nation, but they quickly developed strict control of the monopolies of taxation and justice within the perhaps still-medieval whole. Sudden access to distant resources generated by the changing geopolitical context triggered a number of shifts in public policy, technological advancement, and economics, including shipbuilding. Fifteenth-century ships were a product of the state's will, not the private sector. At this time, states had the political capacity to enforce rules and the economic capacity to plan and launch war at a scale unmatched during the previous Middle Ages (Mendes 1993).

FIGURE 1. Portuguese *nau* from *Livro de Lisuarte de Abreu*, a mid-16th-century manuscript. (Abreu 1558.)

During the late-16th century, the Iberian Peninsula was a cosmopolitan region harboring the bureaucracies that ruled over two extensive empires, and it attracted foreign scholars, merchants, and intellectuals to its major cities. Based on naval power, both the Spanish and the Portuguese empires required a steady stream of larger and better ships, and those built in the Basque country and in Portugal were considered among the best in the world (Escalante de Mendoza 1575:450). This boom lasted for more than 100 years until the 17th century, when the Basque economy based on the whaling industry of the North Atlantic collapsed. Basque shipbuilding suffered as well, both in the design quality and construction (Serrano Mangas 1985:11–46).

Historical information for this period, both documents and iconography, reveals that all Iberian oceangoing ships were conceived in a similar way, regardless of region, city, or shipyard.

Following the Mediterranean shipbuilding tradition, ships were built empirically, based on proportion and scale, and did not require plans or drawings (Rieth 1996:39–50). Built in a carvel style with flush-laid planks fastened to the frames, Iberian oceangoing ships followed a construction tradition thought to date back to the time of oared vessels in the Mediterranean. Even the earliest of the carvel hulls used a number of frames with predesigned curvatures. These frames were mounted over the keel prior to planking, thus defining the shape of the hull (Figure 2).

Cultural Influences

Baltic Influence

Portugal and Spain traded with the Baltic starting in the 14th century, exchanging cereals, metals, and textiles for salt, cork, olive oil, wine, and wool. Permanent commercial relations between Lisbon and Danzig were established in 1430, and there is evidence that Portuguese merchants bought vessels in the north, from Galician, Basque, or British origins (Albuquerque 1994:484). Cross-cultural influence undoubtedly took place. Several Portuguese and Spanish shipwrecks from this period have mast steps that show a northern influence when compared with the Mediterranean ones of similar vessels (Rieth 1998:181). Rectangular dovetail joints between floor timbers and first futtocks have also been recorded. These differ from the traditional Mediterranean hooked scarves, also found on shipwrecks, including the early-14th-century *Culip VI*, the 16th-century Ottoman shipwreck of *Yassı Ada,* and the late-17th-century shipwreck *Sardinaux* (Rieth 1998:184).

Italian Influence

It is curious that in England, as in Venice, predesigned frames were placed at regular intervals along the entire axis of the hull, while in Portugal and Spain the predesigned frames were clustered in the central portion of the ship's hull (Adams 2003:124; Bondioli 2003:223–224).

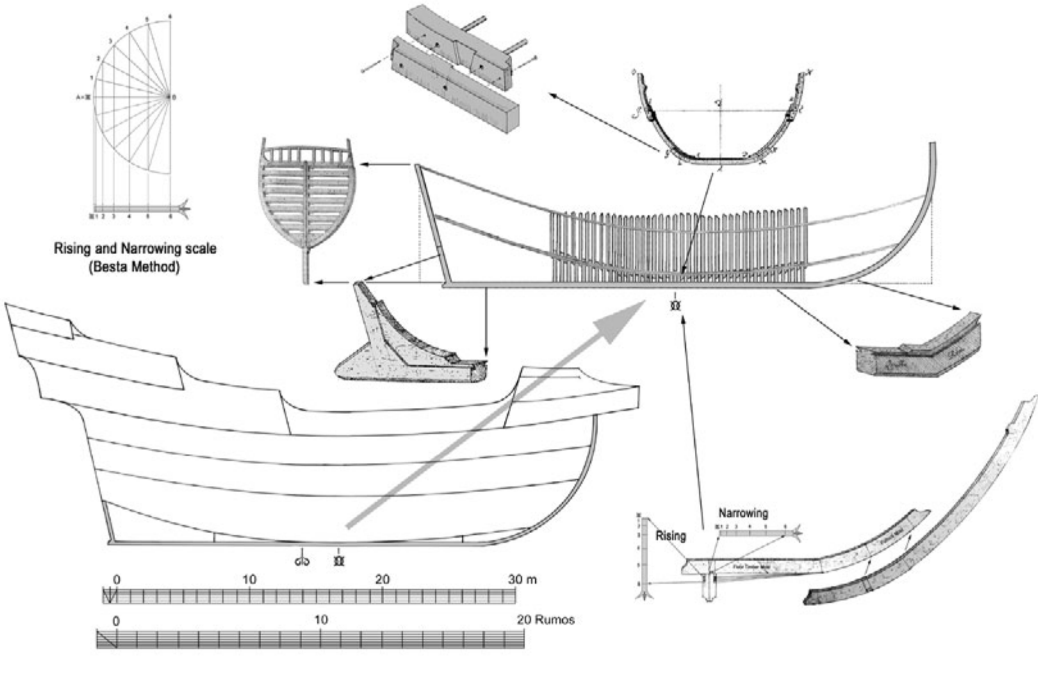

FIGURE 2. Some of Iberian ships' main traits: a number of predesigned and preassembled central frames; floors and futtocks assembled with dovetail scarves; curved timbers connecting the keel and the posts; rising and narrowing of ship's bottom obtained by the whole molding system. (Drawing by author, 2006.)

Ribbands stretched around the erected frames from stem to stern defined the remaining shape of the hull. The stern frames and bow frames were shaped to conform to the curvature defined by the ribbands (Sarsfield 1991). From the top of the first futtocks upwards, next to nothing is known about the construction sequence and the shipwrights' methods of controlling the hull shape. Documentary sources are vague, and the archaeological evidence is scarce.

Considering the Platonic view of the world that held sway at the time, it has been hypothesized that ships would have been conceived from a number of basic measurements that were all proportionally related, such as keel length, maximum beam, hold depth, and overall length (Barata 1989:212–223). Yet, even with a shared worldview, the construction methodologies and units of measurement were loose enough to ensure inevitable variation.

Contemporary documents and archaeological remains indicate that there was variation in the shapes and sizes of ships during this period (Xavier 1992; Philips 2000). Nevertheless, 16th-century state shipbuilding was among the earliest preindustrial trades that incorporated the complexities and basic characteristics of industrial production: division and specialization of labor, execution of sequential and repetitive tasks, and stock management at a large scale, all carried out within a multilayered hierarchical and bureaucratic organization.

Although this method did not require plans or drawings, rules and practices necessarily were as precise as possible because the ability to create symmetry, the key to a good ship, required extensive control of the shipbuilding process.

The parallel between English and Venetian frame design most likely relates to the employment of Venetian shipwrights by Henry VIII in the mid-16th century (Glasgow 1970:10,24). Mediterranean influence on Iberian shipbuilding is explained by a long and continuous economic relationship with the city-state of Genoa, documented as early as the 12th century, when Bishop Gelmirez invited Italian shipwrights from Pisa to build and operate a fleet of galleys charged with protecting the Galician coast (Filgueiras 1989:543–544).

By the late-13th century, Genoese ships began visiting the Bay of Biscay's coast, setting up intermediate trading points for their commercial enterprise in the northern Atlantic. Already trading with Muslim Seville, the Genoese established a permanent presence in the city soon after it capitulated to Alfonso X in 1248. By the second half of the 15th century, the Genoese community in Seville had grown quite large (Pike 1966).

The relations among and influence by the Genoese and Portuguese sailors and shipwrights are fairly well documented and reflected in the shift of units of measure. By the 16th century, Portuguese shipwrights used the *goa* (77 cm) and the *palmo de goa* (25.67 cm) for shipbuilding. Both of these units of measure have a perfect parallel in Genoese units of measure (Ciciliot 1998:27; Barker 2001:214).

Italian influence on Spanish and Portuguese courts was continuous from the 13th to the 15th centuries. Evidence for this tight relationship is seen in recorded relations of private individuals, the documented voyages to the Canaries of Lanzaroto Malocello, Niccoloso da Recco, and Angiolilo del Tegghia de' Corbizzi, as well as the contracted services of the Italians Antoniotto Usodimare and Alvise Cadamosto by Portugal's Infante D. Henrique to sail his caravels down the coast of Africa (Albuquerque 1994:535–536).

These contacts continued into the 15th and 16th centuries, even 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 (Ciciliot 2000). Throughout the 15th and 16th centuries, evidence of similar contracts for Italian shipwrights to work in Portuguese shipyards exists (Viterbo 1988:280,425,452,458,521).

The Italian connections certainly had an important impact on Spanish and Portuguese state-driven shipbuilding industries. Italian merchant cities such as Naples, Genoa, and Venice were home to highly developed shipbuilding industries, having highly organized shipyards where craftsmen were divided into specialized groups: woodcutters, sawyers, carpenters, and caulkers working within the enclosed shipyard complex. Organized shipyards with specialized sets of labor were able to construct the ships quickly in a reliable and repetitive fashion (Lane 1934a, 1934b).

Arab Influence

Arabs were great shipbuilders who may have used frame-based vessels since the 8th century. The author of The Book of Animals, Gahiz (or al-Jahiz) (born A.D. 776), mentions an Umayyad governor of Iraq named al-Haggag, who died in A.D. 714 and is reputed to have built the first vessels "nailed and caulked." Other Arab references from the 10th 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). It is fair to assume that the Arab world was another source of influence on Iberian shipbuilders. Iberian Muslims were a major naval power in the Mediterranean. Arab warships helped make the conquest of the Iberian Peninsula possible. Arab navies fought Viking invaders and later sacked coastal villages with regularity when the Christian leaders started the push against Muslim rule. Reconquista, as the Arab occupation of the Iberian Peninsula is known, lasted more than 10 generations, from the 12th to the 15th century, and encompassed periods of peace and cooperation as well as substantial sharing of cultural ideas.

After the Reconquista, the Arab population in the southern Iberian Peninsula was not expelled. Christianized Arabs went on building boats and ships under the new Christian rulers. The shipbuilding industry appears to have remained robust, possibly because of the widespread piracy in the region. It is likely that the southern Iberian Christianized Arabs were engaged in seasonal piratical incursions into the Maghrib, Arabic for the northwest area of Africa. These raids had to be carried out by sea. Because Arabs remained along the southern Iberian Peninsula, Arab influence permeated the region's culture. People in this area adopted Arab values, practices, and vocabulary. For instance *almogama*, the Portuguese word for tail frame, literally translates as "meeting point" in Arabic. Since there was no lack of Italian designations for this specific timber, the fact that Portuguese shipwrights adopted an Arab word reveals how closely integrated the cultures were within the shipbuilding profession. This is further substantiated by the writings of Father Oliveira who wrote about his visits to harbors and shipyards of Spain, France, Italy, England, and "some in the lands of the Moors" where he observed how they built their ships. He also wrote about how he "practiced with their carpenters, and learning their styles, and carpentry customs, and construction traditions." Known for his candor, Oliveira mentioned the Maghrib harbors and shipyards together with the Italian and the Spanish counterparts without expressing any particular criticism. It is very likely that shipbuilding in the Maghrib was as good and sophisticated as in any other major seafaring country of the time (Oliveira 1580:56).

The Iberian Ship

One of the questions asked previously is whether there is a unique artifactual component or characteristic in ships that can be identified as wholly Iberian. First, it is important to note that Iberian Atlantic ships, as these ships are sometimes called, were built on the Atlantic coast of Iberia primarily to sail on the Atlantic Ocean.

From the discussions on units of measurement, type, size, and cultural influence, it is apparent that Iberian ship designs shared similarities with their other European and Mediterranean contemporaries. Even with limited documentation and iconography, it seems clear that three-masted, carvel-built vessels in the Mediterranean, the Iberian Peninsula, and England during the 16th century were not that different from one another. There were certainly regional differences, differences in units of measurement, and differences in many details but not in the overall style and basic design. If one excludes the Portuguese India *naus*, much larger than all the other merchantmen of their time, fit for the six- to eight-month voyage to the Indian subcontinent, most small or medium-sized oceangoing ships must have looked similar to the nonprofessional eye. Once again turning to the accounts of Oliveira, it is not evident in his writings that he found these small and medium-sized merchant craft fundamentally different. In fact, he appears to have been more inclined to create a Rosetta Stone, as it were, of ship terminology. In his 1580 writings, he states that the ships that the Spanish and Portuguese called *naos,* the Italian called *carracas*, and the German called *urcas* were equivalent (Oliveira 1580:76). Evidence from the north of Europe suggests that the differences between Iberian and Mediterranean ships were either less important or less apparent since Portuguese ships are frequently referred to as *carracks*.

Since at the macro level there does not appear to be significant differences for Iberian ships, the next step is to examine particular construction traits. Clusters of specific traits with regard to construction provide indications of cultural signature. Any individual trait might be shared with other cultures, but clusters will be unique. The problems with this type of analysis stem from the ability to differentiate among overall Iberian and specific regions as well as the shifting patterns of clustered traits over time.

Thomas Oertling has proposed the existence of an Iberian shipbuilding tradition based on a cluster of 11 traits (Table 9) (Oertling 1989, 2001, 2005). His hypothesis is based on archaeological evidence found on several shipwrecks. There are scholars who support Oertling's findings and those who do not. The detractors argue that although the sample shipwrecks were engaged in Iberian trade, there is no way to confirm that they were all actually built in Iberia.

Eric Rieth (1998:178–180) argues that when common traits appear in a large enough number of shipwrecks from the same cultural horizon, they comprise "architectural signatures" that constitute the defining characteristics of a shipbuilding tradition. The Oertling Trait Cluster is the "architectural signature" of Iberian shipbuilding (Figure 2).

Iberian Trait Cluster Signature

The first trait is a given number of preassembled and predesigned central frames. Dovetail scarves are recorded on all Iberian ships, varying only in shape. Both the Pepper Wreck and *Atocha* had rectangular scarf joints (Castro 2005b) (Brian Jordan, 1998, pers. comm.), while the early 16th-century Genoese shipwreck from Villefranche, thought to be the *Lomelina*, had both dovetail and hooked scarf joints (Rieth 1998:183–184).

The second trait relates to the way hull planks are fastened to the frames, specifically the use of iron fastenings. In contrast, the use of treenails varies. The shipwrecks of Cais do Sodré and the *Nossa Senhora dos Mártires* exhibited only iron fastenings (Rodrigues et al. 2001:375–377; Castro 2005b:136).

The third and forth traits pertain to the use of a curved timber (*couce*) at the juncture between the keel and sternpost. The *couce* is reinforced with a curved stern knee. Over the paired *couce* and stern knee sit the y-shaped frames called *picas*. In all instances, save one, that of the Emanuel Point shipwreck, thought to be one of

TABLE 9
IBERIAN ATLANTIC VESSELS: CHARACTERISTICS PROPOSED BY THOMAS OERTLING (2001)

1	A given number of pre-assembled central frames bearing dovetail joints.
2	Carvel planking fastened with a combination of nails and treenails.
3	A knee joining the after end of the keel and the sternpost (*couce*).
4	A single piece deadwood knee over the *couce* upon which sit the y-frames (*coral*).
5	Y-frames tabbed into the deadwood knee.
6	Keelson notched over the floors.
7	Mast step is an expanded portion of the keelson, part of which is cut to seat the ship's pump.
8	Buttresses supporting the mast step against the footwale.
9	Ceiling extending only over the floors, the last strake notched to receive filler planks.
10	Teardrop-shaped iron strop accepting a deadeye attached to two or three lengths of chain, the last link through an eyebolt.
11	Flat transom with proud sternpost.

the 1559 Tristan de Luna's ships, this combination was observed (Smith et al. 1995:35).

The fifth trait pertains to the carved tabs on the upper face of the stern knee. The tabs receive the y-shaped *picas*. This trait is not universal, only occurring in about 40% of the shipwrecks recorded. This trait, besides occurring in Iberian shipwrecks, also occurs on a few Mediterranean shipwrecks, such as the Calvi I shipwreck (Villié 1990:103).

The sixth trait is a notched keelson, which is widespread across many traditions. The *Mary Rose*'s keelson is notched to receive frames (Marsden 2003:95), as is the Woolwich shipwreck (Salisbury 1961:85).

The seventh and eighth traits pertain to the mast-step assemblage. On Iberian ships, the keelson widens at the mast step and is buttressed. The buttresses lock against bottom stringers. This seems to be a solution common to other shipbuilding traditions, specifically in the north of Europe. The Newport ship, a clinker-built vessel dated to the second half of the 15th century has such a mast step. In contrast, Mediterranean examples exhibit a mast-step arrangement that rests between two sister keelsons. This is the case in the Genoese *Lomelina* shipwreck (Guérout et al. 1989:72–77,86; Rieth 1998:181).

The ninth trait pertains to the ceiling arrangement. Filler planks are inserted between the futtocks sealing the lower bilge underneath the ceiling planking. The only other example of fillers come from the Calvi I shipwreck, built in the Mediterranean in the late-16th century (Villié 1989:27, 1990:95–96).

The tenth trait is the use of teardrop-shaped, iron strops. Although this is a prevalent characteristic among Iberian ships, the deadeyes of the *Mary Rose* are also teardrop shaped (Marsden 2003:108).

The eleventh trait calls for flat stern panels. These first appear in the Basque iconography in the last quarter of the 15th century and then again around 1500 in a view of the port of Venice by Jacopo Barbari (Taras Pevni 2002, pers. comm.) (Casado Soto 1995:40; Bash 2000). In the mid-16th century, flat panels appear on a Basque whaling ship at Red Bay, Labrador, but at the same time, contemporary iconography shows what seems to be both round and flat sterns (Figure 3) (Grenier et al. 1994). This may be an example of a trait that shifts through time or of a specific style of vessel.

To these 11 traits might be added another specific feature that does not show up with any regularity in the archaeological record. Written sources suggest a distinctive amidships section on Iberian ships that is neither common to the contemporary ships of the Mediterranean nor northern Europe. Iberian amidships sections are round and full, appearing to derive from a single

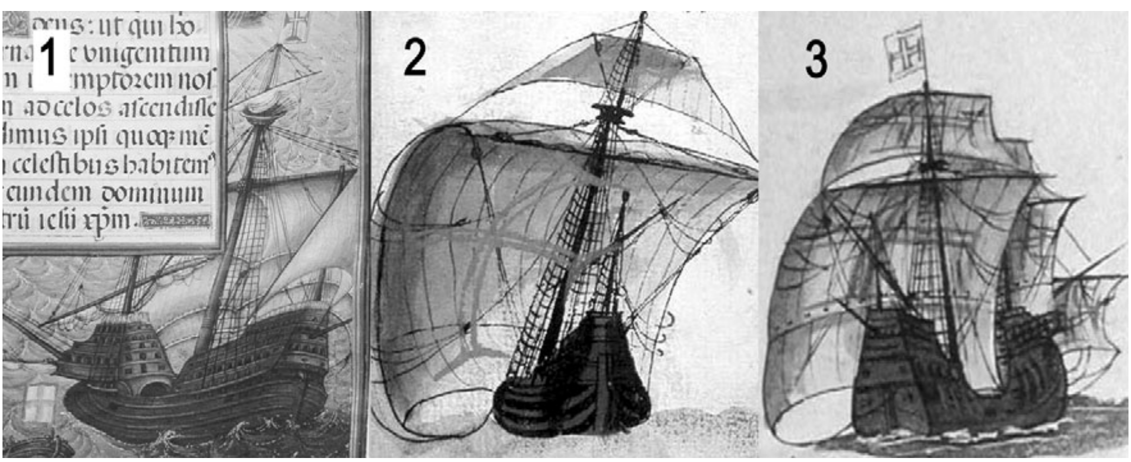

FIGURE 3. Round and square sterns of Portuguese ships after mid-16th-century manuscripts: (1) Livro da Condessa de Bertianos (anonymous, codex from library of Lisbon's Science Academy); (2) *Livro de Lisuarte de Abreu* (Abreu 1558); (3) Livro da Memória das Armadas (anonymous, codex from library of Lisbon's Science Academy).

arc. Mediterranean manuscripts from 150 years earlier exhibit a similar amidships section; however, 15th- and 16th-century Mediterranean and English amidships sections are often depicted as a composite of several arcs (Figure 4).

An argument can also be made for the presence of combined traits being an indicator of Iberian ship designs. The Iberian Peninsula was a nexus of Mediterranean and European cultures, and there are three of Oertling's Iberian shipbuilding traits that potentially reflect this unique area's ability to absorb and integrate diverse ship design components into hybrids. The presence of scarved frames, exhibiting both dovetail and hooked scarves, reflects influence from two sources of shipbuilding design, as does the presence of flat-panel sterns and round sterns. In addition, the ability of an Iberian ship to pass in the North Atlantic as a *carrack* and at the same time pass in the Mediterranean as another type of vessel may reflect the Iberian ship's hybrid nature. Thus, it may be just as important to look for the hybrid as a distinctive look that incorporates multiple traits.

Looking at other forms of evidence, there is some support for the existence of particular subtypes, although samples remain so small as to be inconclusive. For example, there is little information regarding the types of wood used to build Iberian ships. Portuguese treatises recommend cork oak for the structure of the Indiamen and pine for the planking. This was exactly what was found on the Pepper Wreck, an early-17th-century Portuguese Indiaman thought to be the *Nossa Senhora dos Mártires*, lost near Lisbon in 1606. All other vessels whose timbers were sampled and identified exhibit a range of Iberian oak species and a few other types of hardwood, but nothing conclusive. To date, there are no dendrochronological series for the Iberian Peninsula. Finally, a comparison of contemporary iconography shows some typical features, such as an almost complete lack of decorations, especially in the Portuguese long-sea merchantmen. On the other hand, most early-16th-century depictions of Portuguese ships show a red cross painted on the fore and mainsails.

Iberian Ship Types

Since the portion of hull preserved on most shipwrecks is usually small, it is difficult to separate typologies from archaeological evidence. Documentary evidence shows there were three main types of sailing ships: naos, galleons, and caravels.

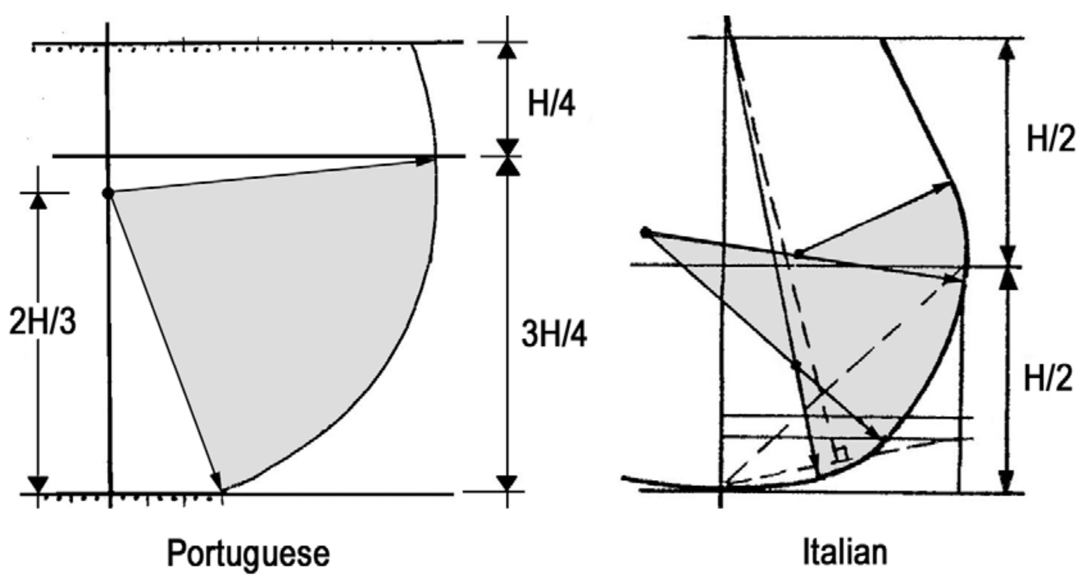

FIGURE 4. Midship sections: Portuguese after Fernando Oliveira (ca. 1580); and Italian after Matthew Baker (ca. 1570). (After Barker 1986.)

The Spanish word nao (in Portuguese *nau*) means vessel but refers to a ship with two, three or four decks and fully integrated fore and stern castles, bearing three masts and a bowsprit, all rigged with square sails, except the mizzenmast. The mizzenmast, intended for steering, was rigged with a lateen sail. As mentioned above, the first depiction of a three-mast, full-rigged ship appears in a Catalan drawing dating to 1409 (Mott 1997:146). The length-to-breadth ratio of the vessel in the Catalan drawing appears to have been around 3:1. This is a common ratio for Mediterranean round ships. Where iconography differentiates between other styles and naos, it is clear that naos have both square and round sterns (Figure 3).

Galleons are mentioned in the first decade of the 16th century and primarily functioned as warships with two or three decks, fully integrated fore and stern castles, three or four masts, and a bowsprit. The fore and main masts were rigged with square sails, and the mizzen and bonaventure masts were rigged with lateen sails. The length-to-beam ratio appears to have been slightly higher than that of the naos, around 3:5. Contemporary galleon scantling lists show a much sturdier vessel with thicker masts and spars (Domingues 2005:366–373). Flat stern panels seem to be a characteristic of these ships, understandably, since a square stern allows for more deck space during military operations, specifically in regard to the movement of stern guns.

Caravels were originally lateen-rigged ships with one or two masts. Generally thought to have developed in the Mediterranean during the 12th century, caravels were mainly employed in fishing activities in Portugal, in the 13th century (Fonseca 1934; Pires 1985, 1986, 1988, 1990; Domingues 1989; Ciciliot 1999). Absent from original documents throughout the 14th century, caravels reappear in the beginning of the 15th century as the preferred "Ships of Discovery," sometimes bearing painted eyes on both sides of the bow, a trait paralleled in the Mediterranean since ancient times (Marques 1998). No doubt, this preference reflects the vessel's swiftness and maneuverability (Pico 1964:73–83). Towards the end of the 15th century, there are references to three-mast, ship rigged caravels, and the 16th century witnessed the development of the *caravela de armada* with four masts and rigged on all masts with lateen sails, except the foremast, which bore square sails. Caravels were still in use in the 17th century, as reported in the 1616 Manoel Fernandez treatise, and sailing around Cape Horn (Fernandez 1616; Vaughan 1913; Vicente Maroto 2001), and they continue to be mentioned in the 18th century (Domingues 2005:259). All vessels of the time were armed and traveled in fleets for added protection. A number of smaller vessels, such as *patachos*, *zabras*, and *galizabras* sailed regularly with the fleets, as supporting craft, and may have been conceived and built in the same way as the larger ships.

Treatises on Iberian Ships

Although this discussion has focused on an Iberian design concept, it is important to note that two major geopolitical entities, Spain and Portugal, inhabit the same mass of land. Their languages, although similar, are recognizably different. Their units of measure are different, and thus the manuscripts and treatises that describe shipbuilding differ. To fully understand an Iberian concept, it is important to understand the similarities and differences of the manuscripts describing shipbuilding.

Spanish Ships Described in Shipbuilding Treatises

Spanish ships are described in several late-16th and early-17th-century texts, of which some contain detailed information. The best descriptions are collectively presented in the three manuscripts by Juan Escalante de Mendoza, *Itinerario de Navegación de los Mares y Tierras Occidentales* (1575), Tomé Cano's *Arte para Fabricar, Fortificar y Apareiar naos* (1611), and Diego García de Palacio, *Instrucción nautica para el buen uso de las naos, su traça, y gobierno conforme à la altura de México* (1587). García de Palacio's work was the first ship treatise ever printed. The later work, *Dialogos entre un vizcaino y un montañez*, dates to 1631 or 1632 and is attributed to the experienced shipbuilder Pedro Lopez de Soto (Vicente Maroto 1998). These manuscripts in combination with the codified three sets of legislation, known as the *Ordenanzas* and issued in 1607, 1613, and 1618, form the main reservoir of Spanish ship architectural documentation (Philips 1987, 1993).

Although modern calculation of early Spanish ship tonnage is a difficult subject, ship's sizes were well documented, both in Spain and in Portugal (Casado Soto 1988). The sizeable sample of registered ship sizes reveals that Spanish *naos* for the *Carreira da Índia* during the first half of the 16th century averaged around 100 metric tons burden, close to 200 metric tons displacement, and doubled their size, on average, during the second half of that century (Pérez-Mallaína 1998:93). The trend towards growth of the merchantmen's sizes, felt during the 16th century, seems to have encountered opposition in the beginning of the 17th century, and efforts were made to standardize ship shapes and sizes (Barcelos 1899; Costa 1997).

Escalante de Mendoza (1575) mentions in his treatise on navigation that *naos* of 500 tons burden were the best fit for the New World route. Soon after, García de Palacio (1587) states that 400 tons burden is a good size for commerce and war.

The *Ordenanzas* of 1607 created legislation that 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. Cano (1611) described a *naos* measuring 12 *codos* in breadth as having a capacity of 232 tons. The important factor is that the proportions of these vessels did not change much, in spite of any change in size (Philips 1993).

In Spain, formulas were used to calculate a ship's capacity since the middle of the 16th century, and it is likely that it was the same in Portugal (Casado Soto 1988:102–109). Historical documents, however, 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 1997:64).

Portuguese Ships Described in Shipbuilding Treatises

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. Yet, both shipbuilding traditions appear to have consistently increased vessel size during the first part of the 16th century (Costa 1997:437–439). By 1571 the capacity of Indiamen was fixed between 350 and 500 tons burden, but how this capacity was calculated is unknown.

Portuguese shipbuilding treatises describing vessels in the late-16th and early-17th centuries contain detailed illustrations and information. The most extensive are the two treatises of Oliveira, *Ars nautica* (1570) and *Livro da fabrica das naus* (1580). The works of João Baptista Lavanha's *Livro primeiro de arquitectura naval* (ca.1610), and Manoel Fernandez's *Livro de traças de carpintaria* (1616) are also important and informative documents (Domingues 2005; Philips 2000). 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 clearly indicate that the ships intended for the India route were consistently larger than the ships built and sailed in the European, Mediterranean, and African trade. Sailing routes between the Iberian Peninsula, northern Europe, the Mediterranean, the western coast of Africa, and 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-16th century.

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 archaeological record, a consistent image of Iberian vessels emerges, making a compelling argument for the existence of an Iberian Atlantic shipbuilding tradition. No single argument, trait, or point of view conclusively settles the question. It is the combination or sum of the parts, seen as a whole, that provides a compelling argument: at the nexus of European and Mediterranean shipbuilding on the Iberian Peninsula, a unique cultural tradition in shipbuilding evolved. It was the rounded midship, the presence of dovetail scarves, the proportions, and the basic measurement units that all melded to create the Iberian ship design, what Reith refers to as "*un air de famille*" (Xavier 1992; Philips 2000; Alves 2001).

One can only hope that at least some Iberian shipwrecks found in the future will be scientifically studied, adding to the sample of collected data and possibly solving some of the ongoing questions. Questions about the tangent of stemposts to keels, consistent proportional arcs in the stempost and bow, 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. Many other issues also beg further research: the question of the *dentes* or little protrusions in the frames drawn in Lavanha and Fernandez's treatises; 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—all need to be checked and criticized against archaeological data.

Only further scientific research of archaeological 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 I write these last lines, the court trials of a number of prominent antique dealers and museum conservators are unfolding and showing, perhaps for the first time, the enormous extent of the destruction inflicted by looters, fueled by the antiques market, on the archaeological record worldwide (Watson and Todeschini 2006). Portuguese and Spanish shipwrecks have been systematically destroyed by treasure hunters worldwide, sometimes with the cooperation of professional archaeologists (Bound 2004; Castro and Fitzgerald 2006). Perhaps this article will contribute to a better understanding of the importance of these ships and their protection against looting and treasure hunting.

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