THE TWELVE APOSTLES: DESIGN, CONSTRUCTION, AND FUNCTION OF LATE 16TH-CENTURY SPANISH GALLEONS

A Dissertation

by

JOSE LUIS CASABAN BANACLOCHA

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Chair of Committee,	Cemal Pulak
Committee Members,	Kevin Crisman
	James Bradford
	Donny Hamilton
Head of Department,	Cynthia Werner

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ABSTRACT

The development of the Spanish galleon as a specialized warship took place in Spain during the 16th century. A series of prototypes built in Spain in that century incorporated concepts and technological solutions from both the Mediterranean and the Atlantic maritime traditions, and became the basis for this new type of vessel. The Spanish galleon was designed in response to changes in Atlantic trade routes at the beginning of the 16th century when, as a result of Spanish transoceanic expansion, new and more specialized vessels were needed for both the coastal defense of Spain and its overseas territories, as well as to escort the oceanic fleets.

In November 1588, King Philip II of Spain ordered the construction of 12 new galleons of 500, 600, and 800 *toneladas*, four ships of each tonnage, specifically designed as warships. These galleons were to replace the losses that occurred after the failure of the Spanish Armada against England, since the chronic Spanish shortage of warships was aggravated by the loss of some of the best naval units. This decision marked the beginning of the largest shipbuilding program attempted in Spain until that moment. These galleons would became known as the Twelve Apostles.

The present study focuses on the analysis of the design and construction of the Twelve Apostles based on original documents currently held at the Archive of Simancas in Spain, shipbuilding treatises and manuscripts, and archaeological evidence. The documents provide a realistic portrayal of the organizational requirements and challenges of a construction project of such magnitude in the context of a pre-industrial society. Moreover, the comparative analysis of 16th- and 17th-century Spanish designs and survey reports, shipbuilding treatises, manuscripts, ordinances, and shipbuilding contracts reveals the evolution of the ship design in Spain. Finally, the study confirms that the design of the midship sections of the vessels of this period, including those of the Twelve Apostles, was based on the use of a single arc. Therefore, a series of alternative interpretations for the reconstruction of the midship section of Iberian-built vessels is provided based on this method.

DEDICATION

To my parents.

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NOMENCLATURE

AGI	Archivo General de Indias, Seville
AGS	Archivo General de Simancas
Art.	Artículo
BNM	Biblioteca Nacional, Madrid
CMC	Contaduría Mayor de Cuentas
Col.	Colección
Ct.	Contaduría
Doc.	Documento
DRAE	Diccionario de la Real Academia Española
Fol.	Folio
Leg.	Legajo
GYM	Guerra y Marina
MNM	Museo Naval de Madrid
MPD	Mapas, Planos y Dibujos
MP	Mapas y Planos
Ms.	Manuscrito
Núm.	Número
n.	Número
T	Tomo

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CHAPTER I

THE DEVELOPMENT OF THE GALLEON IN SPAIN IN THE 16TH CENTURY (1540-1581)

Introduction

During the 16th century, Spain created an empire whose territories spanned Europe, the Americas, and Asia. Ships became vital to maintain communication between different parts of the empire, and to protect them against other European powers. The Spanish transoceanic expansion would not have been possible without a well-entrenched maritime culture and the technological capability to design, build, and operate the sophisticated large ships required for demanding ocean crossings. The Spanish galleon was the technological response to the new naval and commercial needs that arose from the formation of the first permanent interoceanic system from Asia to Europe via the New World. The design of this new type of vessel was based on a series of prototypes developed during the 16th century that incorporated concepts and technological solutions from both the Mediterranean and the Atlantic maritime traditions.

Other European nations such as England and the Netherlands also developed variants of the galleon during the 16th and 17th centuries, although each nation adapted this ship type to their own specific needs.[1] Most modern works examining this period seem to be dominated by a nationalistic perspective in which only these two nations

[1] Phillips 1994, 104.

possessed the indispensable technology and maritime background necessary for such an endeavor. The rejection or omission of a deeply-rooted Spanish maritime culture and the parallel claim of inferior Spanish shipbuilding technology are based on hypotheses developed primarily to explain the failure of the invasion of England by the Spanish Armada in 1588.[2] Such arguments are clearly erroneous considering that all of the Spanish-built oceangoing galleons that participated in the expedition to England returned safely to Spanish ports, even after engaging English ships and encountering severe storms during their circumnavigation of the British Isles.[3] This pejorative opinion about the seagoing quality of the Spanish galleons prevails in traditional interpretations advanced by northern European maritime historians despite the absence of systematic studies of comparative ship design.[4] A contributing issue is that the 16th century in Spain has not received as much attention with regard to the construction, outfitting, and ship history as have later periods, such as the 17th century. Lastly, it has also been emphasized that the Spanish galleons were multipurpose vessels that could be used as both merchantmen and warships depending on the circumstances.[5] Therefore, this lack of specialization made the Spanish galleons a less effective warship when compared with their English counterparts. However, an analysis of the design process of galleons built for the Spanish crown during the 16th century reveals that they were conceived as

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[2] Stradling 2006, 146.
[3] Casado Soto 2003, 52-65.
[4] Phillips 1994, 99.
[5] Phillips 1994, 103

specialized warships specifically adapted for the demanding transoceanic sailing conditions.

Studies of the origin and development of the Spanish galleon began in the late 18th and 19th centuries with the compilation and transcription of documents from public and private archives related to Spain's maritime history. Naval officers such as Martín Fernández de Navarrete, Juan Sanz de Barutell, and José de Vargas Ponce selected and transcribed documents that included important information related to the design, construction, outfitting, and history of galleons built in Spain during the 16th century.[6] Also during the late 19th century, Cesáreo Fernández Duro published his *Historia de la Armada Española desde la Union de Castilla y Aragon* and the *Disquisiciones Nauticas*. These volumes covered the main events of Spanish maritime history as well as the development of shipbuilding, including that of the Spanish galleon.[7] These studies continued during the 20th century when several authors focused their research on the origin and development of the Spanish galleon as a specialized oceangoing warship. In 1920, Gervasio de Artiñano y de Galdácano published a detailed account of Spanish wooden shipbuilding where he attempted to provide a definition for the Spanish galleon and to identify construction factors that differentiated it from the galleons of other European nations.[8] The development of the Spanish galleon as an oceanic warship has also been studied by Casado Soto, who focused his research on the galleons built before

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[6] Navarrete 1971, 32 vols.; 1825-1837, 5 vols.; 1851, 2 vols.; Col. Sanz de Barutell 1810, 28 vols., see González et al. 1999; Col. Vargas Ponce 29 vols., see Vargas et al. 1979.
[7] Fernández Duro 1895-1903, 9 vols.; 1876-1881, 6 vols.
[8] Artíñano y de Galdácano 1920.

the Spanish Armada of 1588.[9] Finally, Fernández González, Phillips, and Serrano Mangas have studied the technical characteristics and history of Spanish galleons, although their studies are centered on 17th-century galleons.[10]

The origin of the galleon

According to the *Diccionario de la Lengua Española*, the word *galeón* (galleon) is an augmentative of *galea* (galley), and defines a large sailing ship similar to a galley, but with three or four masts and rigged with square sails. Galleons could be warships or merchant vessels.[11] Moreover, Covarrubias in the early 17th century indicated that both the galleon and the galleass took their names from the galley, although the galleon was built stronger and heavier, and could withstand the swells at sea because of its high sides.[12]

The term *galione* (galleon) appeared in the Mediterranean in the late 13th century to define a type of small galley.[13] In the 15th century, the word *galeoni* (galleons) referred to large oared vessels used in Venice for river patrols.[14] *Galeón* (galleon) was also the name of the pinnaces for fishing red bream in northern Spain during the 15th and first half of the 16th century.[15] In 1509, a galleon of 120 tons formed part of the Armada

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9 Casado Soto 1988, 143-53, 294-373; 2003, 52-65.
10 Serrano Mangas 1985; 1989; 1992; 2012; Phillips 1990; 1992; 1994; 2007; Fernández González 2012.
11 DRAE 2014, 1076.
12 Covarrubias et al. 2006, 946.
13 Eberenz 1975,183.
14 Lane 1992, 50. *Galeoni* is the plural of *galeone* in Italian.
15 Sañez Reguart 1791-1795, 2:404-38, Imaz 1994, 79, 102, 217, and Casado Soto 1976-1977, 192 cited in Casado Soto 1991a, 134.

assembled in Spain for the conquest of Oran (Argelia).[16] In Venice, Matteo Bressan was credited with the construction of one of the first seagoing *galleoni* between 1526 and 1530, which showed its naval superiority against the Ottoman galleys during the battle of Prevesa in 1538.[17] Spanish warships are also referred as galleons in French documents of the early-16th century.[18] Moreover, the 1529 "Carta Universal" of Diego Rivera includes representations of ships identified as galleons.[19] Nevertheless, by the early 16th century, the term galleon began to be used in both the Mediterranean and the Atlantic to refer to a new type of merchant and/or naval vessel.

The development of the galleon in Spain

The development of the Spanish galleon was a gradual process based on new ship designs as well as modifications of different types of existing vessels. By the time that the first prototypes of Spanish galleons were built, other types of ships, such as the *nao* or carrack, had been in use for decades in the Atlantic for multiple purposes including trade, warfare, and expeditions that led to the discovery and exploration of the New World. It is generally accepted that the Spanish galleon was the result of the combination of the design characteristics of different types of vessels, including the Mediterranean galley, the Cantabrian *nao* (ship), and even the Portuguese caravel.[20]

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[16] Casado Soto 1998, 175.
[17] Lane 1992, 51; Phillips 1994, 100; Guilmartin 2003, 68.
[18] Phillips 1994, 99.
[19] Phillips 1992, 40.
[20] Casado Soto 1988, 136; Phillips 1994, 102; Guilmartin 2003, 107-8.

Figure 1. Location Cuatro Villas (Cantabria), Biscay, and Gipuzkoa (modified from Google Earth Pro satellite maps).

The geographical context

Most of the major 16th-century Spanish shipbuilding innovations, including that of the Spanish galleon, took place in the shipyards of the Cantabrian coast in northern Spain due to the region's long shipbuilding tradition and the availability of raw materials. The Cantabrian coast was a major shipbuilding region since the 12th century. This area is located towards the Bay of Biscay and includes the provinces of Cuatro Villas (Cantabria), Biscay and Guipúzcoa (Basque Country) (Figure. 1). The shortage of agricultural resources in the region forced its inhabitants, the Cantabrians and Basques, to turn to the sea for food and commerce. In addition, an abundance of raw materials for shipbuilding, timber and iron, favored the development of a shipbuilding industry.[21] The geographical position of the Cantabrian coast on the maritime highway that connected Southern and Northern Europe also exposed its sailors and shipbuilders to maritime technological innovation as well as all ships types that travelled between the Atlantic and Mediterranean worlds.[22] By the end of the 16th century, the combination of all these factors led the King of Spain to order that only the ships built in this area be allowed to take part in the *Carrera de India* (Indies run). [23]

***The* nao**

The main type of ship used along the Cantabrian coast was the *nao*. The *nao* was a fully-rigged merchant ship, and comprised the main component of the merchant and naval fleets of the 14th, 15th, and 16th centuries. The *nao* was also the first major multipurpose vessel in the history of Spanish seafaring. It was a large and wide ship with a short keel and deep hold, having a length-to-breadth ratio of approximately 3.2:1.[24] The *nao* became the ideal ship of the early Indies run due to its large capacity and seaworthiness, and quickly replaced the caravel because of its larger cargo capacity.

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[21] Smith 1993, 51.
[22] Oertling 2004, 134.
[23] Artíñano y de Galdácano 1920, 67-8.
[24] Casado Soto 1991a, 132.

Caravels were used during the first expeditions to the New World due to their shallow draft and ability to sail close to the wind.[25]

Crossing the Atlantic required ships with a capacity of at least 50-60 tons (*toneladas*). This was the minimum space required to carry the necessary provisions for the crew. However, larger ships were required to make the Atlantic crossing profitable.[26] The average cargo capacity of the Cantabrian *nao*, on the other hand, ranged between 120 and 250 tons, and was significantly increased during the reign of Phillip II to 800-900 tons.[27] Thus, *naos* provided sufficient space to carry not only crew, soldiers, and provisions, but also trade goods and passengers.[28] *Naos* were also equipped with a forecastle, a sterncastle that extended up to the main mast, and a cabin on top (Figure. 2**)**. At the beginning of the 16th century, the *nao* was a multipurpose vessel used as either a merchant or a naval vessel depending on the circumstances.[29] That the *nao* was designed as a multipurpose vessel, lacking sufficient specialization for advanced naval warfare, was probably one of the major reasons that led to the development of the galleon. Nevertheless, the word *nao* continued to be used as a generic term to define a large vessel, and a galleon could be referred to as either a galleon or a *nao* in the same document, although these were two different types of vessels.[30] By the mid-16th century,

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[25] Casado Soto 1991a, 138.
[26] Phillips 1992, 39.
[27] Casado Soto 1991a, 132.
[28] Phillips 1992, 40.
[29] Casado Soto 1988, 118-20.
[30] Phillips 1992, 43.

Basque sailors in the northern coast of Spain already distinguished the galleon as a particular ship type with respect to other Atlantic vessel types such as the *naos*.[31]

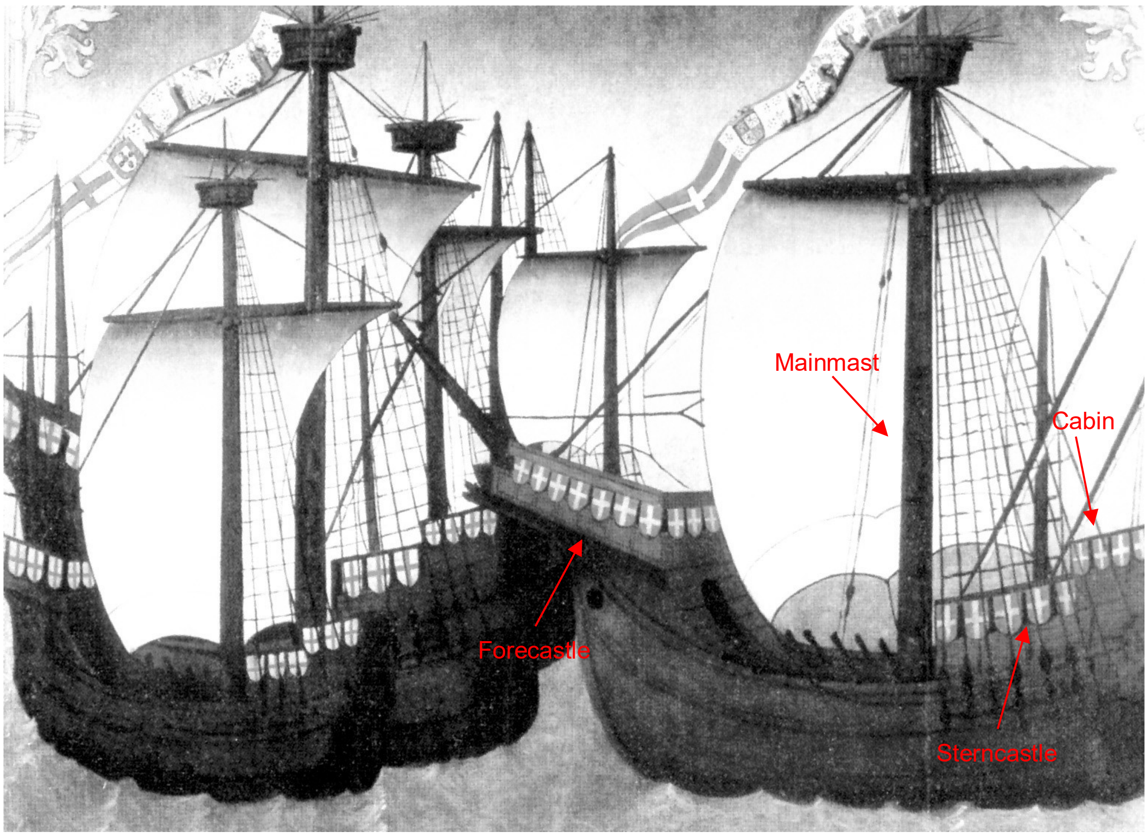

Figure 2. Cantabrian *naos* depicted in the altarpiece of the church of San Pedro de Zumaia (Gipuzkoa), ca. 1480. Naval Museum of San Sebastián (modified from Casado Soto 2006, 19, figure 2).

The requirements of the Atlantic trade routes began to change at the beginning of the 16th century, and new and more specialized ships were needed in Spain for coastal defense purposes and as escorts to the oceanic fleets. The objective was to create a type

[31] Loewen 2007, 3:15.

of vessel that combined the oceangoing capabilities of the *nao* with the speed and maneuverability of the caravel and the Mediterranean galley. In the 16th century, the warship par excellence in the Mediterranean was the galley, a light, fast, and maneuverable vessel propelled by combination of oars and sail. However, the long and low hull of Mediterranean galleys was not the most appropriate configuration for Atlantic conditions. Galley hulls experienced significant stress due to the hogging and sagging created by the high-cresting and widely-spaced large Atlantic waves, in comparison to the low and short-spaced Mediterranean waves.[32] In consequence, putting together oar propulsion and sail power in Atlantic vessels presented a significant technical challenge, since the short keels and high sides required for ocean travel directly opposed the long keels and low sides needed to place thwarts and oarsmen. Different design solutions were attempted to integrate low oared ships and high sided sailing ships on the same vessels. This process led to the development of different types of vessels that included not only the galleon but also the *galeaza* (galleass) and *galizabra*, which shared technical characteristics with galleons (Figure. 3). However, continued difficulties in adapting oars to the Atlantic vessels eventually led to the abandonment of this configuration.

[32] Casado Soto 1988, 136.

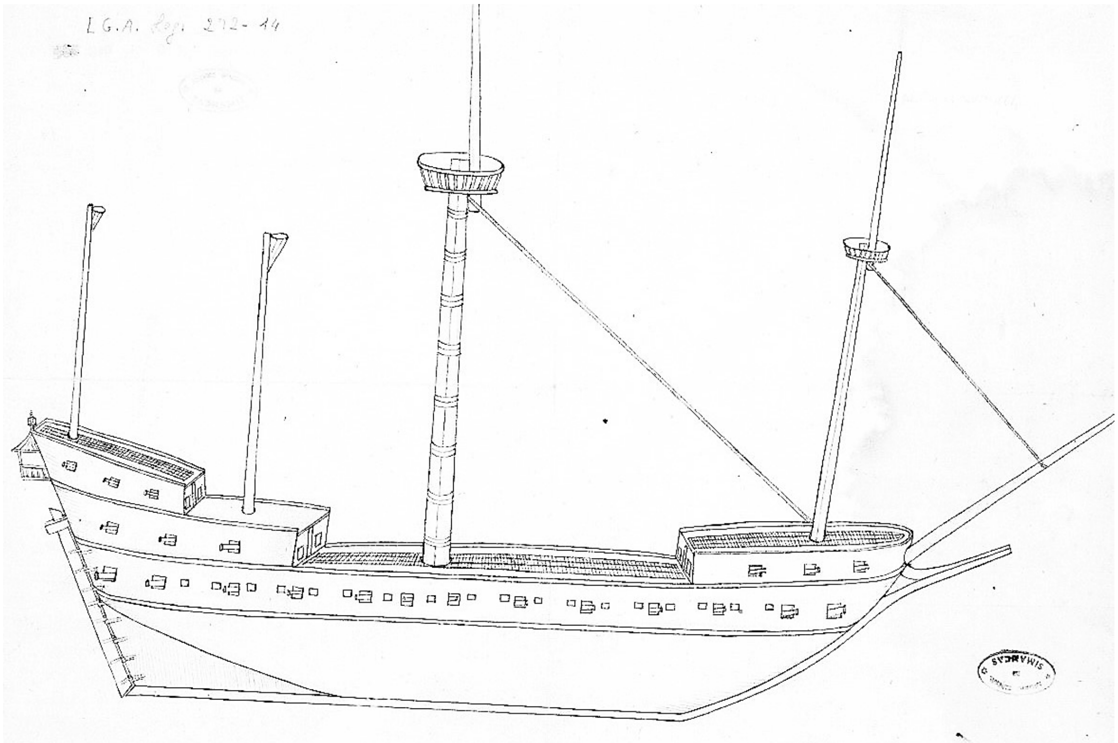

Figure 3. Drawing of a galleass-like ship (*nave agaleazada*) by Gregorio Sarmiento de Valladares, 1589 (after AGS MPD, 16, 164).

Bazán's *galeazas* (galleasses) and *galeones* (galleons) (1540-1550)

One of the first references in Spain to the construction of galleasses and galleons as oceangoing warships is dated to 1540. That year, Álvaro de Bazán *el Viejo* (the Elder) was granted a license by the Crown to build two *galeazas* (galleasses) of 800 and 1200 *toneladas* (tons), and two galleons totaling 1300 tons. These ships were built for coastal defense of the Iberian Peninsula from the Strait of Gibraltar to Fuenterrabía in Guipúzcoa.[33] These vessels were designed specifically as armada vessels (navy vessels),

[33] Col. Sanz de Barutell, Simancas, art. 5, núm. 26, cited in Fernández Duro, 1880, 5:14.

and differed from merchantmen with their specially reinforced hulls.[34] The design of these new types of vessels proved so successful that in 1550, Bazán signed a new contract to build additional galleons and galleasses to escort treasure fleets from the New World to Spain. The new galleons and galleasses were to be 400 tons, but built in a way that their draft was similar to a vessel 100 tons lighter. Galleasses would have two rowing decks, while the galleons would be rowed only from a single deck, the location of which depended on the lading of the ship. If the galleon was fully laden, the oars would be placed on the upper deck (*segunda cubierta*); if unloaded, they would be placed on the main deck (*primera cubierta*). Both galleasses and galleons would have their main decks (*primera cubierta*) caulked and situated one palm (0.21 m) below the waterline.[35] This was to ensure that the ship would not sink if damaged by gunfire shot near the waterline. The galleasses had a central and two side gangways connected with removable wooden gratings similar to hatches (*cuarteles levadizos*) that closed the upper deck from above. The galleons, on the other hand, would have above the upper deck a central gangway and a series of caulked compartments (*cámaras calafateadas*) along the sides of the ship. The space between the compartments and the central gangway would be closed with removable wooden hatches (*cuarteles levadizos*).[36] While these galleons were first attempts in transforming Spanish galleons into warships, they also represent a serious effort in combining sail and oars in an Atlantic warships.

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[34] Phillips 1994, 104.
[35] One Spanish *palmo* equaled ¼ of Castilian yard (*vara castellana*), which measured 835.9 mm. Therefore, the length of a *palmo* was 209 mm. Casado Soto 1988, 60-1.
[36] Fernández Duro, 1880, 5:14-8, also cited in Casado Soto 1988, 139-40.

Galizabras

Another type of vessel developed during this period was the *galizabra*. According to O'Scanlan, the *galizabra* was a vessel used in the Mediterranean rigged with a lateen sail, and having a tonnage of about 100 tons (*toneladas*).[37] However, the *galizabras* built in the 16th century were intended to be vessels with shallow drafts similar to galleys, oared like a *galera sotile*, but also having a continuous deck and anti-boarding netting, as required by Atlantic sailing and warfare. Their tonnage ranged between 120 and 250 casks (*toneles*) but their design characteristics are not well known.[38] Although a rather innovative ship, several reports were sent to the *Consejo Real* (Royal Council) highlighting its flaws.[39] It should be noted that *galizabras* appeared in the musters of the Spanish Armadas of 1596 and 1597, suggesting that this type of vessel was more successful than documents of the first half of the 16th century would have us believe.[40] In any case, the design innovations of galleasses, galleons, and *galizabras* all contributed to the development of the Spanish galleon.[41]

Casado Soto interprets the longitudinal section of the "*asabras*" *Santa Ana* and *María* built in Fuenterrabía in 1591, which appear in a 16th-century document located in the Archive of Simancas (Spain), as the typical design of a *galizabra*.[42] In addition to the longitudinal section of the ships, the document includes their main dimensions and a

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[37] O'Scanlan 1831, 290.
[38] Casado Soto 1991a, 136.
[39] AGS GYM Leg. 38 doc. 274, cited in Casado Soto 1988, 136.
[40] AGS GYM Leg. 468 doc. 61; AGS GYM Leg. 481 doc. 3; AGS GYM Leg. 490 doc. 431.
[41] AGS GYM Leg. 67 doc. 70 and AGS GYM Leg. 38 doc. 274, cited in Casado Soto 1988, 136; 1991a, 136.
[42] AGS MPD, 16, 179.

description of the configuration of their hulls (Figure. 4). The main dimensions of the two ships are almost identical, with minimal variations in the ships' length, keel, and breadth while the depth of hold is the same for both *galizabras*. According to the document, the *Santa Ana* had a length of 37 cubits (*codos*) (21.27 m), a keel length of 27 cubits (15.52 m), a depth of hold (*puntal*) of 5.66 cubits (3.25 m), and a breadth of 12 cubits (56.9 m) minus 0.12 cubits (0.07 m), or 11.87 cubits (6.83 m). The *galizabra María*, on the other hand, had a length of 36.5 cubits (20.99 m), a keel length of 26.5 cubits (15.24 m), a breadth of 12 cubits (6.9 m) minus 2 fingers (*dedos*) (0.035 m) or 11.93 cubits (6.86 m), and the same depth of hold as that of *Santa Ana*. The longitudinal section shows a ship with only one upper deck (*puente*) that also serves as gundeck, and a shallow hold with a maximum height of 5.66 cubits (3.25 m) with a row of unplanked beams three cubits (1.72 m) above the ceiling planking (Table 1).

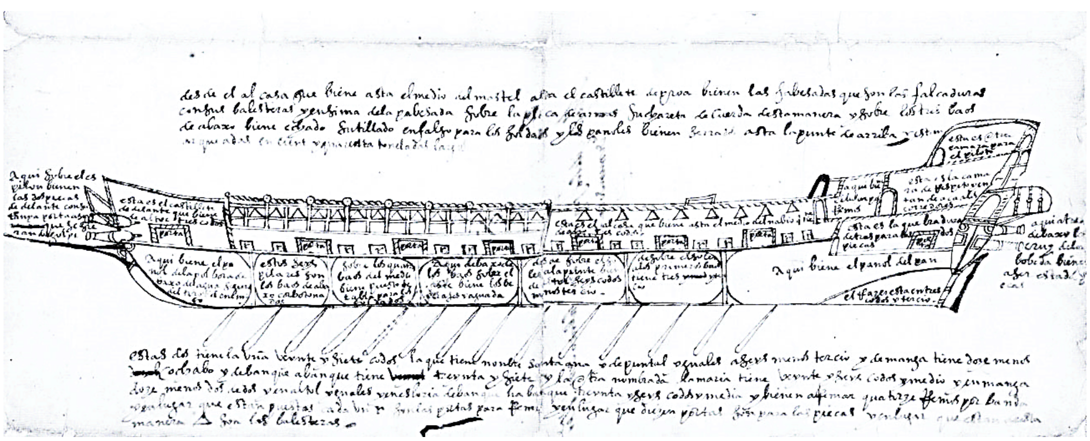

Figure 4. Model of the *asabras* (*galizabras*) built by don Ernando Urtado de Mendoça in Fuenterrabia (Hondarribia) in 1591 (after AGS MPD, 16, 179).

Table 1. Dimensions of the *galizabras María* and *Santa Ana* (1591).

Galizabras	**Length** Cubits (meters)	**Keel** Cubits (meters)	**Breadth** Cubits (meters)	**Height of unplanked beams** Cubits (meters)	**Main deck Depth of Hold** Cubits (meters)
María	36.5 (20.99)	26.5 (15.24)	11.93 (6.86)	3 (1.72)	5.66 (3.25)
Santa Ana	37 (21.27)	27 (15.52)	11.87 (6.83)	3 (1.72)	5.66 (3.25)

According to the number of gunports, the *galizabras* carried eight guns on either side plus two more at the bow, below the forecastle, and two at the stern, below the quarter deck. In addition to sails, the *galizabras* were propelled by 14 oars on either side, with the oar ports distributed in pairs between the gunports. The ships had a forecastle three cubits (1.72 m) high at the bow, which was connected to the sterncastle with an anti-boarding netting. The sterncastle extended from the mainmast to the stern with a steerage and a cabin behind which opened to a gallery. Above the main cabin there was a small cabin for the pilot of the ship. Along the bulwark of the sterncastle and the ship's waist, and below the netting, there was a row of triangular openings/ports (*ballesteras*) for the soldiers to shoot through. The magazine for gunpowder was located at the bow of the *galizabra* below the forecastle, while there was another locker at the stern for bread. The upper deck was broken below the steerage and the main cabin, creating a step to define another compartment which accommodated the two guns located at the stern (Figure. 4) As a result of this step, the floor of the steerage and the main cabin were raised with respect to the level of the upper deck, while the floor of the compartment was lowered. The design of these *galizabras* is similar to the design proposed by Fernandez in his *Livro das traças de Carpinteria* (1616), where the design of a one-decked *galizabra* with a breadth of 35 *palmos de goa* (8.96 m) appears (Figure 5).[43]

Figure 5. Longitudinal view of a *galizabra* (after Fernandes 1989, fols. 109v-110).

The *galeoncetes* (small galleons) of Pedro Menéndez de Avilés (1567)

In 1567, Pedro Menéndez de Avilés was commissioned to build 12 *galeoncetes* (small galleons) for the protection of the Indies run (*La Guarda de la Carrera de Indias*), and to eliminate French and English pirates threatening the Spanish trade routes in the Caribbean. They were known as the first "Twelve Apostles" as they were named after them.[44] As with Bazán's warships, these galleons were also designed to be propelled by either oars or sails. They were built in Deusto by Pedro de Busturria *el Mayor* (the Elder) and Pedro de Busturria *el Joven* (the Younger), under the supervision

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[43] Fernandes 1989, fols. 109v-110; Fernandes et al. 1995, 51-2, fols. 19-20v; 1 *palmo de goa* equals to 0.256 m, in Lavanha and Barker 1996, 108.
[44] Casado Soto 1988, 136; 2003, 48.

of Juan Martínez de Recalde.[45] Their principal dimensions and design were described in two documents dated to 1575 and 1581.

In 1575, Rodrigo de Vargas wrote a report about Menéndez's galley-like galleons of new invention (*galeones agalerados de nueva invencion*) in which he listed their main dimensions and deck configuration, but also their design flaws. In his report, Vargas made a series of recommendations about the design of galleons to be built for privateering and to protect Spanish territories in the New World.[46] A detailed description of these galleons was included in a later design report for a new series of galleons that a committee of shipwrights and naval experts prepared in Santander in 1581.[47] Despite the differences between the two documents in relation to the deck configuration of the galleons, they complement one another and reveal important information about the design of these vessels.

Rodrigo de Vargas's report about Menéndez's* galeoncetes *(1575)

According to Vargas, these galleons were designed to be propelled by oars or sail depending on the circumstances. The document includes the keel lengths (*quilla*), breadths (*manga*), and depth of holds (*puntal*), but does not mention their lengths between perpendiculars (*esloria*).[48] Vargas does not specify the type of cubit (*codo*)

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[45] Casado Soto 2003, 46.
[46] Navarrete 1971, 22.1, doc. 38, fols. 129-131v.
[47] AGS GYM Leg. 111 doc. 166 transcript, in Casado Soto 1988, 300-14; also in Navarrete 1971, 22.1, doc. 76, fols. 292v-295.
[48] The Spanish term *puntal* (depth of hold) defines geometrically the depth of a vessel measured from the top of the ship's floor (*plan*) to the main deck (*cubierta principal*). In addition, the term *puntal* also designates the height or vertical distance between two decks. Moreover, shipbuilders distinguish between

employed in constructing the galleons, although the traditional linear unit used in shipyards of northern Spain was the shipyard cubit (*codo de ribera*) of 33 fingers (*dedos*) (0.575 m).[49] In the document, the galleons had a keel length of 35 cubits (20.13 m), and a breadth of 12.5 cubits (7.19 m), which Vargas considered insufficient (Table 2).[50]

Table 2. Dimensions of Menéndez's *galeoncetes* (small galleons).

GALEONCETES 1567 Small galleons	**Tonnage** (*Toneles*)	**Length** Cubits (meters)	**Keel** Cubits (meters)	**Breadth** Cubits (meters)	**Height (*Puntal*)**		
					Orlop deck Cubits (meters)	**Main deck** Cubits (meters)	**Upper deck** Cubits (meters)
Vargas Report (1575)	200*	-	35**	12.5	-	4	8.5
Barros Report (1581)	230-240	44 (25.3)	30 (17.25)	12-13 (6.9-7.47)	4 (2.3)	7.5 (4.31)	11 (6.3)
San Bartolomé Survey (1571)	280	41.67 (23.96)	-	11.86 (6.82)	-	8.4 (4.84)	-
San Mateo Survey (1571)	273.5	42.16 (24.24)	-	11.86 (6.82)	-	7.76 (4.46)	-
* Tons (*Toneladas*) ** The type of cubit (*codo*) is not specified in the original document.							

The height of the upper deck (*segunda cubierta*) was 8.5 cubits (4.89 m), and the main deck (*primera cubierta*) was located slightly above four cubits (2.3 m) from the

construction and surveying depth of hold (*puntal de arqueo*). Construction depth of hold (*puntal de construcción*) measures at the master floor timber the vertical distance between the upper surface of the keel and the lower face of the beam of the main deck. Surveying depth of hold (*puntal de arqueo*) is the vertical height between the surface of the ceiling planking (*granel*) to the lower surface of the beam of the main deck, and it was used primarily to calculate the tonnage of the ships. O'Scanlan 1831, 442.

49 Casado Soto 1991b, 104.

50 Navarrete 1971, 22.1, doc. 38, fols. 129-131v.

ship's master floor (*plan*).[51] The estimated tonnage provided in the report for the vessels was 200 tons (*toneladas*). According to Vargas, the galleons had only two decks (*cubiertas*), a main deck (*primera cubierta*) and an upper deck (*segunda cubierta*) with a bulwark (*mareaje*) two cubits (1.15 m) high running around of the upper deck from bow to stern. The galleons were not provided with a proper sterncastle (*alcázar*), but fitted with a cabin at the stern from which the upper deck extended forward as a grating (*jareta*) up to the mainmast. In Vargas's opinion, the galleons proved to be good sailing vessels because they were well-proportioned and had a good hull shape (*galibo*).[52]

These vessels were called "galley-like galleons of new design" (*galeones agalerados de nueva invencion*) because they were designed to be rowed from the main deck (*primera cubierta*). However, Vargas mentioned in his report that this deck was at the same level as the waterline, sometimes even below it, and that prevented any attempt to row from there. This location of the deck was to ensure the floatability of the galleons in case of artillery fire that pierced the hull above the waterline during naval combat.[53] This was the same design that Bazán applied to his galleasses and galleons, which would also appear in later designs, including the galleons known as the Twelve Apostles.[54]

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[51] O'Scanlan (1831, 424) defined the floor (*plan*) as the lower and wider part of the bottom of a vessel in the hold; that is almost horizontal to each side of the keel, and it is composed of flat futtocks. Another definition corresponds to the distance between the wrongheads or the turns of the bilge. This distance only serves to calculate the volume of the vessel (*arqueo*), and it is quite imaginary if the floor has too much deadrise. On the other hand, Steffy (1994, 271), the floor is defined as the bottom of the vessel between the upwards turns of its bilges.
[52] O'Scanlan 1831, 289; Navarrete 1971, 22.1, doc. 38, fols. 129-131v.
[53] Navarrete 1971, 22.1, doc. 38, fols. 129-131v.
[54] AGS GYM Leg. 264 doc. 24; AGS GYM Leg. 245 doc. 11.

According to this description, however, the galleons would have a draft of only four cubits (2.3 m) if the main deck was located at the waterline.

In addition, the holds of the galleons were too small to carry provisions and ammunition needed for the crew and soldiers. Two lockers (*pañoles*) were built at the bow and the stern below the main deck to store the gunpowder and bread. As a result, the only space left for ballast was between these two lockers, and therefore drinking water, wine, ammunition and the rest of the provisions had to be placed on the main deck where the soldiers had their accommodation. Moreover, the ordnance could not be placed on the main deck because it was too close to the waterline, and the space was already occupied with the ship's provisions and ammunition. For this reason, the guns were placed on the upper deck, although some of the heavier pieces were unmounted from their carriages and carried in the hold because the upper deck could not withstand their weight.[55]

In an attempt to remedy all these inconveniences, a forecastle was built at the bow, and a sterncastle (*castillo de popa*) at the stern, with its cabin (*cámara*) and a poop deck (*media tolda*). A wooden grating that could be covered with tarred canvas to protect the crew in case of inclement weather connected the sterncastle to the forecastle. Moreover, the height of the bulwarks was also extended vertically, making the *galeoncetes* look larger than they really were. Vargas thought that these galley-like galleons were too large to be rowed effectively, and too small to be considered warships.

[55] Navarrete 1971, 22.1, doc. 38, fol. 130.

The *galeoncetes* were so small that when moored next to a 400-500 tons (*toneladas*) *nao*, they appeared to be the *nao*'s long boat.[56]

In his report Vargas also included a list of recommendations to improve the designs of future oceangoing galleons built specifically as warships for the purposes of privateering or the defense of the Indies. His first recommendation was to increase tonnage of the galleons to 300 tons (*toneladas*) each, while the *Capitana* (Admiral) and *Almiranta* (Vice-admiral) should be 400 tons. The galleons should also have longer keels, wider breadths, and shallower depth of hold, and good entries and runs.[57] He proposed galleons of two decks, with the heaviest artillery placed on the main deck and the lighter pieces on the upper deck. The main deck had to be located high enough above the waterline to allow for the use of guns during heavy weather with high winds and waves, although he did not specify any optimal depth of hold or draft for the ships. The galleons also had to be large enough to carry provisions and ammunition for the crew and at least 150 soldiers.[58] Vargas considered these to be the ideal characteristics and strengths required for the galleons to fight against the English, Dutch, and French in the Indies. In addition, a galleon's keel should be long enough to accommodate a large number of guns and troops for seaborne assaults of any position that could be occupied by the enemy in the Indies. Moreover, a maximum tonnage of 300 tons would ensure that the galleons could enter almost any shallow harbor in the Caribbean.[59] In other

[56] Navarrete 1971, 22.1, doc. 38, fol. 130.
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[57] Navarrete 1971, 22.1, doc. 38, fols. 130-130v.
[58] Navarrete 1971, 22.1, doc. 38, fol. 129v.
[59] Navarrete 1971, 22.1, doc. 38, fols. 130-131v.

words, Vargas's recommendations were focused on producing a new type of vessel specifically designed for amphibious warfare to defend Spanish territories in the Indies. It should be noted that most of his recommendations were incorporated into the design of the next generation of galleons designed and built as warships by Barros in Guarnizo between 1582 and 1583.

The committee of Santander's description of Menéndez's galleons (1581)

In 1580, King Philip II ordered the construction of a new series of galleons to replace Menéndez's *galeoncetes* which, despite their design flaws, had proved more effective than the private merchant vessels that the Crown hired to escort the Indies fleets and to protect the coasts of the Iberian Peninsula.[60] In 1581, two committees, one in Seville and the other in Santander, were assembled to discuss a better design for the new galleons.

The committee of Santander was chaired by Cristóbal de Barros, who in March 1581 sent to the King a design proposal for the new galleons, which included a detailed description of Menéndez's galleons, including their main dimensions, deck configuration, and what the committee considered to be their design flaws. The information about the galleons was provided by ship masters and officials who had sailed them, and also by master carpenters Pedro de Busturria *el Mayor* (the Elder) and

[60] Casado Soto 2003, 53.

Pedro de Busturria *el Menor* (the Younger) who had built them.[61] The examination of this document revealed several discrepancies with Vargas's descriptions for the same vessels, especially in relation to their deck placement and the configuration of the upper works.

According to Barros's document, Menéndez's galleons had a length (*esloría*) of 44 cubits (25.3 m), a keel (*quilla*) length of 30 cubits (17.25 m), and a breadth (*manga*) of 12-13 cubits (6.9-7.47 m). The deck configuration included three decks, with the orlop deck (*primera cubierta*) located at a height of four cubits (2.3 m), the main deck (*puente*) at 7.5 cubits (4.31 m), and the upper deck (*jareta*) at 11 cubits (6.3 m) from the ceiling planking (*soler*). The tonnage of the ships ranged between 230 and 240 casks (*toneles machos*) (Table 2).[62] These dimensions and tonnages closely matched the survey results of the galleons *San Bartolomé* and the *San Mateo* conducted in Seville in 1571. Unfortunately, the survey did not include the keel lengths. The *San Bartolomé* had a length of 41.67 cubits (23.96 m), a breadth of 11.86 cubits (6.82 m), a depth of hold of 8.4 cubits (4.83 m), and a capacity of 280 casks (*toneles*). The dimensions of the *San*

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[61] AGS GYM Leg. 111 doc. 166, in Casado Soto 1988, 307; also in Navarrete 1971, 22.1, doc. 76, fols. 293-293v.

[62] The transcription of the document AGS GYM Leg. 111 doc. 166 is published in Casado Soto 1988, 307-11, also in Navarrete 1971, 22.1, doc. 76, fols. 293-295; One *tonel macho* equaled eight cubic *codos de ribera* (1.52 cubic m). During the 16th century, ships' tonnages were calculated in Spain using a series of arithmetic formulas, which provided the ships volumes in *toneles* (casks). One *tonel* equaled to two *pipas* of wine, although a *tonel macho* was about 10 percent larger than a *tonel* from Andalusia that was calculated using *codos castellanos*. The *tonelada*, on the other hand, was a unit of freight that equaled one *tonel* plus 20 or 25 percent of the estimated tonnage of the vessel. The additional 20-25 percent included the spaces above the vessels' main decks and upper works, and was a bonus for the owners in addition to the basic rates of hire paid by the Crown. The distinction between *tonelada* and *tonel* slowly disappeared from the mid-16th century until 1590 when Philip II standardized the linear and volume units used in Spain for shipbuilding and the *tonelada* became the same as the *tonel*. Casado Soto 1991b, 103-4.

Mateo were similar with a length of 42.16 cubits (24.24 m), an identical breadth of 11.86 cubits (6.82 m), a depth of hold of 7.76 cubits (4.46 m), and a tonnage of 273.5 casks (*toneles*) (Table 2).[63]

The dimensions and deck configuration provided in the later report of the Santander committee differed from that in Vargas's description. While the ships' breadth was nearly identical in both documents, Barros's report gives a keel length that was five cubits (2.88 m) shorter than that in Vargas's description. Both reports agreed, however, that the main design flaw of these vessels was their limited space below decks.

According to Vargas's description, the galleons of Menéndez only had two decks, the main deck (*primera cubierta*), and the upper deck (*segunda cubierta*), while Barros described three decks for the same galleons, an orlop deck (*primera cubierta*), a main deck (*puente*), and an upper deck (*jareta principal*). In addition, Vargas provided a height of four cubits (2.3 m) from the ship's floor (*plan*) to the main deck (*segunda cubierta*), while Barros indicated a depth of hold of 7.5 cubits (4.31 m) from the ceiling planking (*soler*) to the main deck (*puente*), with an orlop deck (*primera cubierta*) situated four cubits (2.3 m) above the ceiling planking. Another discrepancy between the two descriptions was the vertical distance between the main deck and the upper deck of the galleons. In Vargas's report, the vertical distance between the two decks was 4.5 cubits (2.59 m), but only 3.5 cubits (2.01 m) according to Barros. The deck configuration described by Barros is also similar to the results of the 1571 survey in which *San Mateo*

[63] AGI *Contaduría*. Leg. 2933. s. fol., cited in Casado Soto 2003, 46.

has a depth of hold of 7.76 cubits (4.46 m) for the main deck. In contrast, *San Bartolomé* presented a greater depth of hold at 8.4 cubits. The differences between both galleons do not indicate a different design but rather a deviation from the original design during the construction process. Another difference between the reports was related to the ship's capacity. While Vargas estimated the tonnage of the galleons at around 200 tons (*toneladas*), the Barros committee mentions a figure between 230-240 casks (*toneles*), and the survey conducted in 1571 gives a tonnage of 280 and 273.5 casks (*toneles*) (Table 2).[64]

Moreover, in Barros's description, the ordnance was carried on the main deck (*puente*) located at a height of 7.5 cubits (4.31 m), with the gunports situated only one cubit above the main deck, or at a total of 8.5 cubits (4.89 m) above the ceiling planking. The galleons had a cabin for the captain at the stern, and a forecastle. The height of the bulwarks was only 1.5 cubits (0.86 m) so the upper deck between the stern cabin and the forecastle was fully exposed to the elements.[65] This configuration created several problems due to the lack of sufficient space for ballast, provisions, artillery and accommodations for the soldiers and crew. According to the committee, the height between the ceiling planking and the orlop deck was too low to carry all the ballast and provisions needed for the long journey from Spain to the Indies. The ballast occupied most of the hold below the orlop deck, leaving only enough space for a layer of casks

[64] AGI *Contaduría*. Leg. 2933. s. fol., cited in Casado Soto 2003, 46; Navarrete 1971, 22.1, doc. 38, fol. 129, also in Casado Soto 1988, 310.
[65] Navarrete 1971, 22.1, doc. 76, fols. 293-294v., also in Casado Soto 1988, 307-9.

(*pipas*) above it. That meant that the rest of the provisions and ammunition had to be stowed in the lockers between the orlop and main deck. Therefore, the space between the orlop deck (*primera cubierta*) and the main deck (*puente*) was so crammed with victuals and ammunition that, in receiving a shot during a combat, the ship would irremediably flood due to the impossibility to reach the hole in the hull to plug the leak.[66]

The committee's report also included the draft of the galleons, which was 8 cubits (4.6 m). Therefore, if the gunports were at a height of 8.5 cubits (4.89 m), they had to be closed most of the time to prevent water entering into the ship. Consequently, it was almost impossible to use the guns that were unmounted, and thus they were often carried below decks to make room for the soldiers and crew who had no place to occupy other than between the main (*puente*) and the upper deck (*jareta*). Moreover, the capstan and bitts were also located on the main deck limiting the movement of crew and soldiers on that deck. Water entered into the main deck through the grating on the upper deck, soaking artillery and soldiers' arms.[67]

A grating made of ledges (*barrotes*) and ropes supported by top timbers (*barraganetes*) was extended from the stern cabin to the mainmast, and another added atop the forecastle to provide shelter and more space for the crew. The grating added between the stern cabin and the mainmast had a central gangway (*crujía*) which was 3.25 cubits (1.87 m) above the upper deck at a height of 14.25 cubits (8.19 m) from the

[66] AGS GYM Leg. 111 doc. 166, in Casado Soto 1988, 309, also in Navarrete 1971, 22.1, doc. 76, fols. 294-295.
[67] AGS GYM Leg. 111 doc. 166, in Casado Soto 1988, 309-10, also in Navarrete 1971, 22.1, doc. 76, fols. 293-294.

ceiling planking, and the space left between the top of the bulwark and the grating was covered with canvas or planking depending on the galleon. As a result of these additions, the small galleons seemed larger than they really were, although the grating also increased the height of the vessels, which required additional ballasting and increased the ship's windage. The committee also indicated in the report that the galleons had narrow breadths and floor lengths that increased the ships' draft, and the keels were too short for ships designed as warships.[68]

The committee's report further indicated that the galleons were not sufficiently strong to be considered warships or Armada vessels because they had been built with unseasoned timber and thin planking. Moreover, their hulls needed to be reinforced in order to withstand the weight and recoil of the guns, and to handle the extra rigging and sails needed to drive such heavy vessels. The galleons were also too small to fight against larger enemy vessels; as many as five of them were needed to attack other ships. The conclusion of the committee of experts was that the next series of warships to be built had to be larger to carry sufficient provisions for the crew and soldiers on long voyages to the Indies, and to challenge larger vessels or privateers.[69]

Despite the discrepancies, Vargas's description revealed important information about the design of these vessels that was not included in the committee's report. Perhaps the most important feature mentioned by Vargas was that these vessels were

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[68] AGS GYM Leg. 111 doc. 166, in Casado Soto 1988, 307-8, also in Navarrete 1971, 22.1, doc. 76, fols. 293-294.
[69] AGS GYM Leg. 111 doc. 166, in Casado Soto 1988, 307-11, also in Navarrete 1971, 22.1, doc. 76, fols. 293-295.

new inventions, designed to be propelled by oars and sails similar to the galleons and galleasses built by Bazán in 1540 and 1550. Unfortunately, their deep draft prevented the efficient use of oars.

It has to be noted that the design of these small galleons presents many similarities with the *galizabras* built in 1591 in Fuenterrabía, based on comparing Vargas's deck configuration and the description of the upper works provided by both the reports by Vargas and Barros. In fact, Phillips refers to the small galleons of Menéndez as *galizabras* although this term does not appear in either report.[70] Another feature shared with Bazán's designs was the presence of an orlop deck located below the waterline to prevent the sinking of the vessel in case of gunfire damage close to the ship's waterline.

The galleass *San Cristóbal* (1578)

Before Barros built the next series of galleons in the early 1580s, he constructed two galleasses in 1578 to serve as the *Capitana* (Admiral) and *Almiranta* (Vice-admiral) of the Indies fleet.[71] These vessels were built in Deusto, near Bilbao, Spain, the same place where in 1589 Agustín de Ojeda would build six of the new Twelve Apostles. One of the galleasses was lost shortly after its construction on the sandbar of Sanlúcar, at the mouth of the Guadalquivir River, in 1579. The other galleass, *San Cristóbal*, crossed the Atlantic several times, including the expedition to colonize the Strait of Magellan from

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[70] Phillips 1992, 54.
[71] AGS GYM Leg. 83 doc. 197 and 198, in Casado Soto 2003, 49.

which only a few vessels returned.[72] The *San Cristóbal* had a reputation as a seaworthy vessel, and therefore its design and dimensions were mentioned in later design proposals for other vessels, including the Twelve Apostles and Barros's previous series of galleons. In fact, Barros recommended following the design of *San Cristóbal* when building four largest Apostles.[73]

The description that Barros provided in 1589 indicated that *San Cristóbal* was larger than Menéndez's galleons with an estimated tonnage of 900 casks (*toneles*) if gauged as a warship, and 800 casks (*toneles*) as a merchant ship.[74] Barros also gave the ship's main dimensions and deck configuration, but only up to the main deck (*segunda cubierta*). The configuration of the remaining decks, upper works, and gratings was the same as the galleons he built in the early 1580s. The *San Cristóbal* had a keel length of 42 cubits (24.15 m), 38 cubits (21.85 m) of clean keel (*quilla limpia*) and four cubits of gripe (*asiento llano del branque*),[75] with a length of 63 cubits (36.22 m) measured at a height of 11 cubits (6.32 m) from the ceiling planking (*soler*), and a breadth of 19 cubits (10.92 m). It had a row of unplanked beams located at five cubits (2.88 m), the orlop deck was 9 cubits (5.17 m) from the ceiling planking, and the depth of hold of the main deck (*segunda cubierta*) was 12.5 cubits (7.19 m), which was also the location where the breadth or maximum width of the ship was measured. According to Barros's instructions, the upper deck and grating of the galleass (*jareta*) would follow the same

[72] Casado Soto 2006, 49-51.
[73] AGS GYM Leg. 245 doc. 11.
[74] AGS GYM Leg. 245 doc. 11.
[75] This measurement corresponded to the distance between the inner intersections of the stem and sternpost with the upper surface of the keel. Gaztañeta 1720, 19, also in Hormaechea et al. 2012, 1: 280.

configuration as his later series of galleons, although no exact figure was indicated in the report for *San Cristóbal* (Table 3).[76]

Table 3. Dimensions of galleass *San Cristóbal* (1578). Units given in cubits (1 cubit = 0.575 m).

Vessels	**Tonnage** *Toneles*	**Length** Cubits (meters)	**Keel** Cubits (meters)	**Breadth** Cubits (meters)	**Floor** Cubits (meters)	**Height (Puntal)**				
						Unplanked beams Cubits (meters)	**Orlop deck** Cubits (meters)	**Main deck** Cubits (meters)	**Maximum breadth** Cubits (meters)	**Upper deck** Cubits (meters)
Galleass San Cristobal (1578)	Merchant 800 Warship 900	63 (36.22)	38 (21.85)	19 (10.92) 18 (10.35)	-	5 (2.88)	9 (10.92)	12.5 (7.19)	12.5 (7.19)	-

This design showed that the space limitation observed in Menéndez's galleons had been addressed by increasing the space below the lower deck, which now included a row of unplanked beams (*baos vacíos*) to reinforce the lower part of the hull. Nevertheless, their tonnage was still lower than Bazán's galleasses. The main design flaw of *San Cristóbal*, despite its good sailing capabilities, was its deep draft due to the narrow breadth of its hull. The committee of experts that designed the Twelve Apostles in 1589, and evaluated Barros's proposals, determined that the galleass *San Cristóbal* had a breadth of less than 18 cubits (10.35 m) and a draft of 13 cubits (7.48 m), which required high tide for the galleass to sail over Sanlúcar's sandbar.[77] As in previous designs, the galleass had its orlop deck placed below the waterline to ensure the buoyancy of the ship in case of damage at or below the waterline, although the main

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[76] AGS GYM Leg. 245 doc. 11.
[77] AGS GYM Leg. 245 doc. 11.

deck for the heavy artillery was at about the same level as the ship's maximum draft, actually 0.5 cubits (0.29 m) cubit lower than the maximum draft.[78]

The galleons of Cristóbal de Barros (1581-1583)

The last series of galleons built as warships before the construction of the Twelve Apostles were the nine vessels that Barros built in Guarnizo between 1582 and 1583. These galleons were to replace Menéndez's *galeoncetes,* which, despite their design flaws, proved very effective as escorts of the Indies fleets and in the protection of the coasts of the Iberian Peninsula. The decision to build these new galleons was made in a meeting that took place in Lisbon in November 1580. During the meeting, representatives of the House of Trade (*Casa de la Contratación*), naval commanders, and shipbuilding experts under the presidency of Bazán decided to build eight galleons whose design would be based on Menéndez's *galeoncetes*.[79]

The design process for these galleons was based on the recommendations of two committees, one in Seville and the other in Santander. The committees consisted of shipwrights, naval commanders, and ship masters who, during 1581, prepared separate proposals about what they considered to be the best dimensions and technical characteristics for the galleons. Cristóbal de Barros chaired the Santander committee, while the one in Seville was made up of experienced naval commanders such as Diego Flores and Pedro Sarmiento, who also prepared their own design reports apart from that

[78] AGS GYM Leg. 245 doc. 11.
[79] Casado Soto 1988, 143; 2003, 53.

of the committee. In addition to these committees, anonymous reviewers evaluated the design reports sent to the King by the committees of Santander and Seville. In total, four different designs were proposed for the new series of galleons.

The design of Diego Flores de Valdés (February 1581)

In February 1581, Diego Flores submitted his own design for the new series of galleons to be built, which included only minor variations with respect to the galley-like galleons of Menéndez. It should be noted that, according to Flores's design, his dimensions corresponded to Barros's description of the Menéndez galleons. [80] In his design, Flores retained the lengths and keel dimensions of the previous galleons. He also added a forecastle and a sterncastle although the sterncastle only extended half of the distance from the stern to the mainmast. A grating (*jareta*) with a central gangway (*crujía*) extended from the sterncastle to the main mast, and another grating with the same configuration from the mainmast to the forecastle. The ship also had a row of unplanked beams at a height of five cubits (2.88 m), and the depth of hold of the main deck (*cubierta principal*) was increased by half a cubit (0.29 m) up to eight cubits (4.6 m) to facilitate the use of artillery (Table 4).[81] In the galleons of Menéndez, the main deck (*segunda cubierta*) was almost at the same level as the ship's waterline, which made it impossible to use the guns in inclement weather or strong winds.

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[80] Navarrete 1971, 22.1, doc. 76, fols. 286v-287, also in Casado Soto 1988, 294-95; AGS GYM Leg. 111 doc. 166, in Casado Soto 1988, 307-11; also in Navarrete 1971, 22.1, doc. 76, fols. 293-295.
[81] Navarrete 1971, 22.1, doc. 76, fols. 286v-87, also in Casado Soto 1988, 294-95.

Table 4. Dimensions of Barros's galleons (1581).

Vessels	Tonnage *Toneles*	Length Cubits (meters)	Keel Cubits (meters)	Breadth Cubits (meters)	Floor Cubits (meters)	Height (Puntal)				
						Unplanked beams Cubits (meters)	**Orlop deck** Cubits (meters)	**Main deck** Cubits (meters)	**Maximum breadth** Cubits (meters)	**Upper deck** Cubits (meters)
Galleons Diego Flores (Feb 1581)	300-450*	44 (25.3)	30 (17.25)	12.5-13.5 (7.19-7.76)	-	5 (2.88)	-	8 (4.6)	-	-
Galleons Santander (March 1581)	Merchant 345 Warship 416	55 (31.62)	37-38 (21.28-21.85)	16 (9.2)	6 (3.45)	-	5.75 (3.31)	9.08 (5.22)	-	12.33 (7.09)
Small Galleons Seville (August 1581)	300*	50** (27.9)	33 (18.41)	15 (8.37)	-	4 (2.23)	-	7 (3.9)	-	10.25 (5.72)
Small Galleons Santander (Sep 1581)	420	52 (29.9)	34 (19.55)	15 (8.62)	-	-	-	6 (3.45)	9 (5.18)	9.5 (5.46)
Large Galleons Seville (August 1581)	450*	55** (30.69 m)	36 (20.09)	16.5 (9.2)	-	4.5 (2.51)	-	7.75 (4.32)	-	11 (6.14)
Large Galleons Santander (Sep 1581)	550	56 (32.2)	35 (20.13)	16 (9.2)	-	4 (2.3)	-	7.5 (4.3)	9 (5.18)	11 (6.32)

* *Toneladas* (Tons)
** *Codos Castellanos* (Castilian Cubits)

The ships' breadth in Flores's design was extended by half a cubit to increase their volume to 300 tons (*toneladas*), except for those of the *Capitana* (Admiral) and *Almiranta* (Vice-Admiral), which were increased to 450 tons (*toneladas*). Flores insisted that the galleons had to be fitted with two pieces of artillery at the bow, and the wales and gunports should be at different levels to prevent crossing each other. Moreover, the gratings had to be placed at the height of a man to allow soldiers to move about and fight freely. The galleons' hulls also needed a more pronounced sheer to prevent sagging due to their long lengths. Flores recommended building nine galleons instead of only eight to ensure that there were always four galleons with the *Capitana* if the squadron was divided. Finally, he insisted that the person in charge of the construction should have sailing experience to ensure that the vessels were well proportioned, and to modify their dimensions during construction if deemed necessary.[82]

The first design of the Santander committee (March 1581)

Cristóbal de Barros and the committee of Santander prepared a second proposal almost a month after Diego Flores's proposal was submitted. After listing the design flaws observed in the galleons of Menéndez, Barros's committee proposed a model that basically followed the designs of Menéndez and Flores with minor modifications. In his proposal, Barros increased the lengths of the keels to 37 or 38 cubits (21.28 or 21.85 m) in order to reduce the rake of the bow. Therefore, it is plausible that the ship lengths were increased proportionally up to 55 cubits (31.62 m) as designed by Menéndez and Barros. This proposal did not include the breadth of the ships although it was also probably increased proportionally according to the other main dimensions up to 16 cubits (9. 2m). It did, however, mention the length of the main floor. According to the report, one of the main design flaws of Menéndez's galleons was the narrowness of the ships' floors, which increased their draft and contributed to the sagging of the hulls due to the weight of the ordnance. In the new design, the floor length increased to six cubits

[82] Navarrete 1971, 22.1, doc. 76, fols. 286v-287, also in Casado Soto 1988, 294-95.

(3.45 m) between the points marking the turn of the bilge (*puntos de escoa*), without the wrongheads (*escarpes*), and to eight cubits (4.6 m) when including them (Table 4).[83]

In Barros's proposal, the height from the ceiling planking to the orlop deck (*primera cubierta*) was 5.75 cubits (3.31 m) to ensure enough space to carry all the provisions and ammunitions needed for a journey regardless of its length. This height increased 0.75 cubits (0.43 m) compared to Flores's design, and by 1.75 cubits (1 m) in relation to Menéndez's design. The orlop deck was to be caulked and located below the waterline, and accommodate the crew and soldiers of the vessel. In contrast, the height between the lower deck (*primera cubierta*) and the main deck (*puente* or *segunda cubierta*) was reduced to 3.33 cubits (1.91 m) although the overall depth of hold increased to 9.08 cubits (5.22 m) with respect to both previous designs. The height between the main deck and the upper deck (*jareta*) was 3.25 cubits (1.87 m), with the ordnance located on the main deck (Table 4). The configuration of the upper decks, however, remained identical to Flores's and Menéndez's designs. The ships had a cabin (*cámara*) for the captain on the sterncastle (*chimenea*) and a planked roof (*tillado*) to shelter the steersman up to the mizzenmast, and a removable netting with a central gangway (*crujía*) extended from the planked roof to the mainmast. The space between the bulwarks and the grating could be covered with removable planking up to the top timbers (*barraganetes*) or in a permanent manner. The ships also had a forecastle (*castillete*) at the bow with a light grating (*jareta*) on top. According to the committee's

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[83] AGS GYM Leg. 111 doc. 166, in Casado Soto 1988, 300-14.Navarrete 1971, 22.1, doc. 76, fols. 292v-296v.

proposal, the galleons would have tonnages of 345 *toneles machos* as merchantmen, and 416 *toneles machos* as warships, but with the same draft as Menéndez's galleons. The estimated cost of each galleon was 10,000 ducats.[84]

The examination of both the designs of Flores and Barros shows that they followed the same galley-like design philosophy of Menéndez's galleons. Their designs introduced only minor variations in deck configuration of the vessels to reduce the draft of the ships and to ensure that artillery could be used despite adverse sea conditions. These galleons were long and shallow with minimum upper works, only a cabin occupying half of the length of the sterncastle. Even the grating was light and limited to the forecastle and the space between the cabin and the main mast. Neither Flores nor Barros mentioned in their reports the use of oars to propel their vessels.

The design of the Seville committee (August 1581)

In the summer of 1581, a committee in Seville consisting of Diego Flores, Pedro Sarmiento, and naval experts of the House of Trade (*Casa de Contratación*) prepared a new design proposal for galleons to be built as escorts for the Indies fleets.[85] The report was sent to Santander for evaluation by Barros and his committee. The design report prepared in Seville featured a new type of galleon that, despite being based on

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[84] AGS GYM Leg. 111 doc. 166 in Casado Soto 1988, 311-13; Navarrete 1971, 22.1, doc. 76, fols. 295v-296v.
[85] Navarrete 1971, 22.1, doc. 76, fols. 314-315v, in Casado Soto 1988, 347-49.

Menéndez's ships, would set the basic warship type to be built in the last decades of the 16th century in Spain, including the Twelve Apostles.

All dimensions included in the Seville committee's report were expressed in *codos castellanos* (Castilian cubits), which equals 2/3 of a *vara* or 32 fingers (0.558 m). This was the typical linear dimension unit used in shipyards on the Atlantic coast of Andalusia. The Castilian cubit was one finger shorter than the *codo de ribera* traditionally used in the north of Spain, in the area of Biscay and Cuatro Villas, which measured 2/3 of a Castilian yard (*vara*) plus one finger (*dedos*), or 33 fingers (0.575 m).[86] The main dimensions proposed for the *Capitana* and *Almiranta* were a length of 55 cubits (30.69 m) and a keel length of 36 cubits (20.09 m), both shorter than the design of the Barros's committee but longer than the Menéndez and Flores proposals. The breadth of the ships was also increased to 16.5 cubits (9.2 m) although the total height of the main deck decreased to 11 cubits (6.14 m), similar to Menéndez's *galeoncetes* but more than a cubit (0.558 m) lower than the designs of both Flores and Barros (Table 4).[87]

With respect to the deck configuration, the committee of Seville proposed a height for the row of unplanked deck beams (*baos vacíos*) of 4.5 cubits (2.51 m), while the main deck (*baos tillados*[planked beams]) was located 3.25 cubits (1.81 m) above the unplanked beams, with the upper deck (*puente firme*) 3.25 cubits (1.81 m) above the

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[86] Casado Soto 1988, 66-7; Casado Soto 1991b, 103-4.
[87] Navarrete 1971, 22.1, doc. 76, fol. 314, in Casado Soto 1988, 347.

main deck. This configuration added a row of unplanked deck beams in comparison to the first design of the Santander's committee (Table 4).[88]

The galleons also had a sterncastle (*alcázar*) that extended from the stern to the mainmast, a grating (*jareta*), and a forecastle (*castillo*) 3.5 cubits (1.95 m) above the main deck (*puente*). The grating between the forecastle and the sterncastle (*jareta*) had a central gangway (*crujía*) and planked sides, with a wooden grating (*red de madera*) between them that could be covered with tarred canvas to protect those below in case of foul weather. The sterncastle, grating, and forecastle were located 3.5 cubits (1.95 m) above the main deck to allow the soldiers more clearance to stand and fight below them (Table 4).[89]

A poop deck (*toldilla*) was situated 3.5 cubits (1.95 m) above the sterncastle (*alcazar*), which extended up to the mizzenmast. Another grating with a gangway in the center extended from the poop deck to the main mast, and the same configuration occurred on top of the forecastle. Finally, the design proposal recommended connecting the gratings of the poop and forecastle with an anti-boarding netting (*falsa jareta*) made of chains. The riding bitts (*abita*), hawse holes (*escobenes*), capstan (*cabrestante*), and the helm port (*lemera*) were located at a height of 11 cubits. The riding bitts had to be moved towards the stern in order to allow enough room for two pieces of artillery with

[88] Navarrete 1971, 22.1, doc. 76, fol. 314, in Casado Soto 1988, 347.
[89] Navarrete 1971, 22.1, doc. 76, fol. 314, in Casado Soto 1988, 347.

two gunports to be opened as close as possible to the bow. Moreover, four more gunports were to be opened at the stern, two on either side of the helm port.[90]

The rest of the galleons had smaller dimensions than the *Capitana* and *Almiranta,* although they kept the same configuration for the upper works. According to the design report, they would have a length of 50 cubits (27.9 m), a keel length of 33 cubits (18.41 m), a breadth of 15 cubits (8.37 m), and a depth of hold of 7 cubits (3.9 m) (Table 4). Therefore, Seville's small galleons were still longer and wider than those of previous designs, although they required a longer bow rake because their keels were shorter than those in Santander's report. The row of unplanked beams (*baos sin tillar*) was situated at a height of 4 cubits (2.23 m), the main deck 3 cubits (1.67 m) above them, and the upper deck 3.25 cubits (1.81 m) above the lower deck (Table 4). The sterncastle, grating, and forecastle were to follow the same specifications as for the larger galleons. The estimated tonnages for the *Capitana* and *Almiranta* were 450 *toneladas*, and 300 for the others although these volumes referred to the cargo capacity as merchant vessels. The design proposal also recommended that the gunports be placed between the wales without cutting them. The committee of Seville recommend the construction of 12 of this type of galleons.[91]

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[90] Navarrete 1971, 22.1, doc. 76, fols. 314-315, in Casado Soto 1988, 347-48.
[91] Navarrete 1971, 22.1, doc. 76, fols. 315-315v, in Casado Soto 1988, 349.

The final design of the Santander committee (September 1581)

At the end of the summer of 1581, Barros and the Santander committee sent a report to the King, which included their own design report that eventually was the version used in the construction of this series of galleons.[92] Among the members of the Santander committee were two individuals named Busturria, father and son, who were responsible for the construction of Menéndez's *galeoncetes*, and one of them, probably the son, was also later involved in the construction of the Apostles in 1589 in the shipyard of Deusto.

Barros and the Santander committee evaluated Seville's proposal positively, although they modified the main dimensions of the galleons. The *codos castellanos* of the Seville report were converted into *codos de ribera* used in the shipyards of northern Spain.[93] According to the conversion, 30 *codos de ribera* (17.25 m) equaled 31 *codos castellanos* (17.30 m). Therefore, in the case of the main dimensions of the *Capitana* and *Almiranta*, the breadth of 16.5 *codos castellanos* (9.21 m) became 16 *codos de ribera* (9.2 m), and 36 *codos castellanos* (20.09 m) of the keel became 35 *codos de ribera* (20.13 m). The only main dimension of the Seville proposal that was modified and not simply converted was the length of the ship, which was extended to 56 *codos de ribera* (32.2 m) from the 53.5 (30.76 m) that had resulted from converting the original 55 *codos castellanos* (30.69 m). This extension was to ensure a good proportion between the keel

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[92] AGS GYM Leg. 117 doc. 98, in Casado Soto 1988, 350-53; also in Navarrete 1971, 22.1, doc. 76, fol. 315-318.
[93] Casado Soto 1988, 66-7; 1991b, 103-4.

and ship's length, and to fair the rakes at the bow and stern of the galleons. The Santander report was the first to specify the height at which the ship's breadth or maximum width was located. According to Barros, the maximum width should be located at a height of over nine cubits (5.18 m) from the ceiling planking (*soler*), two cubits (1.15 m) below the upper deck (*segunda cubierta*) (Table 4).[94]

The deck configuration in the Santander report was identical to those given in the proposal of the Seville committee, with only minor variations in deck heights. The row of unplanked beams (*baos*) were located at four *codos de ribera* (2.3 m), and the main deck (*cubierta principal*) 3.5 cubits (2.01 m) above the unplanked beams.[95] The upper deck (*segunda cubierta*) was located at a slightly higher level than in the Seville design due to the conversion of units.[96] The upper deck in Barros's design was located 3.5 cubits (2.01 m) above the main deck, 0.25 cubits (0.14 m) higher than in the Seville report, although the total height was 11 cubits (6.32 m) in both proposals. However, due to conversion of units, the upper deck in the Santander proposal was almost 0.5 cubits (0.29 m) higher than in the Seville report.

The configuration of the sterncastle (*chimenea*), grating (*jareta*), and forecastle (*batallera*) was identical in the two designs, although Barros increased their height in the Santander report to 3.75 cubits (2.16 m) because the artillery was located on the main deck and to allow free movement of people because the fighting took place here. There

[94] AGS GYM Leg. 117 doc. 98, in Casado Soto 1988, 351; also in Navarrete 1971, 22.1, doc. 76, fols. 316-316v.
[95] AGS GYM Leg. 117 doc. 98, in Casado Soto1988, 351; Navarrete 1971, 22.1, doc. 76, fols. 316v.
[96] AGS GYM Leg. 117 doc. 98, in Casado Soto 1988, 351; also in Navarrete 1971, 22.1, doc. 76, fols. 316-31v.

was also a cabin for the admiral (*cámara*) and a poop deck (*media chimenea*) above the sterncastle (*chimenea*) that extended almost up to the mizzen mast, as a planked roof (*tillado*) to provide cover for the helmsman.[97] Another grating (*jareta*) with its gangways extended from the poop deck to the mainmast, above beams supported by hanging knees to reinforce the ship's upper works. A removable anti-boarding netting could be extended from the mainmast to forecastle (*batallera*), which was probably fitted with another fixed grating, although the design proposal did not mention it. Another change introduced by Barros and his Santander committee was the location of the capstan and bitts, which were moved above the quarterdeck in order to facilitate fighting on the main deck and below the gratings.[98]

With respect to the dimensions for the smaller galleons, Barros and his committee proposed a length of 52 cubits (29.9 m), and a keel length of 34 cubits (19.55 m), which was two cubits (1.15 m) shorter than in Seville's proposal design even after the cubit conversion. The ship's breadth of 15 cubits (8.62 m) was located at a height of nine cubits (5.18 m). In this case, the ship's breadth was 0.5 cubits (0.29 m) wider than in the Seville proposal due to the unit conversion. The deck configuration also varied in comparison to the Barros design for the large galleons, and to the Seville proposal for the small ones. The depth of hold of the small galleons was 6 cubits (3.45 m) although they did not have a row of unplanked beams (*baos*) between the ceiling planking (*soler*)

[97] AGS GYM Leg. 117 doc. 98, in Casado Soto 1988, 351-52; Navarrete 1971, 22.1, doc. 76, fols. 316-317.
[98] AGS GYM Leg. 117 doc. 98, in Casado Soto 1988, 351-52; Navarrete 1971, 22.1, doc. 76, fols. 316-317.

and the main deck (*primera cubierta*), which was located at a height of six cubits (3.45 m). Instead of the beams, the lower part of the hull was reinforced with riders (*bularcamas*) that extended from the tops of floors to above the turn of the bilge. The shelf clamps (*durmientes*) for the upper deck were located at a height of five cubits (2.88 m); with the thickness of the deck beams and planking, the upper surface of the main deck (*primera cubierta*) was at the aforementioned height of six cubits (3.45 m). The upper deck (*segunda cubierta*) was 3.5 cubits (2.01 m) above the main deck, with a total height of 9.5 cubits (5.46 m) from the ceiling planking (*soler*), almost 0.5 cubits (0.29 m) lower than the design proposed in the Seville proposal for the small galleons (Table 4). The configuration of the upper works was the same as for those of the *Capitana* and *Almiranta* despite the different size of the galleons. According to Barros, the estimated tonnage for the large galleons was 550 *toneles machos* while that of the smaller ones was only 420 *toneles* (Table 4).[99]

At the end of 1581, the King ordered Barros to build the galleons following the specifications based on the Santander committee's final report. The initial number of galleons to be built was increased from eight to nine, as Flores had recommended in his first proposal. In addition, the King ordered the reduction of the tonnage of the galleons to 400 *toneladas* for the largest, and 300 *toneladas* for the other galleons in order for them to be able to enter shallow rivers and ports.[100] The keels of the galleons were laid

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[99] AGS GYM Leg. 117 doc. 98 in Casado Soto 1988, 352-53; Navarrete 1971, 22.1, doc. 76, fols. 317-318.
[100] AGS GYM Leg. 121 doc. 194, in Casado Soto 1988, 360-61.

in 1582 in the shipyard of Guarnizo (Santander), and all were launched between April and August, 1583.[101]

Eight of these galleons took part in the expedition of the Great Armada against England in 1588, as part of the Squadron of Castile. Despite the severe storms suffered by the ships of the Armada while circumnavigating the British Isles, these galleons all returned safely to Spain, proving their seaworthiness. According to Casado Soto, this series of galleons became the prototype from which oceangoing Spanish galleons would develop in the following decades, including the Twelve Apostles. [102] In fact, these galleons had certain deficiencies in their design that had to be addressed in the next series of galleons. The breadths of Barros's galleons were too narrow, and they had deep drafts that did not permit the use of artillery on the main deck in stormy weather or strong winds.[103] The design of these galleons was severely criticized by the members of a new committee of experts assembled in Santander at the end of 1588 and early 1589 to discuss the design of the Twelve Apostles. Despite Barros's claims about the quality and sailing capabilities of his galleons, including the galleasses he built in 1578, his designs and dimensions were not used in the next series of galleons, except for the configuration of the upper works.

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[101] AGS GYM Leg. 129 doc. 237 and AGS GYM Leg. 131 doc. 52, in Casado Soto 2003, 60-61.; AGS GYM Leg. 144 doc. 113. AGS GYM Leg. 145 doc. 23. AGS GYM Leg. 146. Doc. 82, in Casado Soto 2003, 61.
[102] Casado Soto 2003, 52-65.
[103] AGS GYM Leg. 245 doc. 11.

CHAPTER II

THE CONSTRUCTION OF THE TWELVE APOSTLES

The last week of November 1588, King Philip II of Spain ordered the construction of 12 new galleons of 500, 600, and 800 *toneladas*, four ships of each tonnage. These galleons were to replace the losses incurred after the failure of the Spanish Armada against England, since the chronic Spanish shortage of warships was aggravated by the loss of some of the best naval units. This decision marked the beginning of the largest shipbuilding program attempted in Spain until that moment.

The King entrusted the organization of the shipbuilding program to Joan de Cardona, a member of the Council of War. Cardona was already in Santander in charge of refitting the surviving ill-fated Armada ships to render them operational as soon as possible.[1] His orders included the organization of a committee of shipwrights, experienced ship masters, and captains to determine the dimensions, moulds, and technical characteristics of the new vessels that were to be specifically designed as warships. The King also ordered Cristóbal de Barros and Agustín de Ojeda to participate in the committee, since they were to be in charge of the construction of the galleons

[1] AGS GYM Leg. 244 doc. 267; BN Ms. 2058, fol. 13, cited in Goodman 1997, 7; Cardona was an experienced galley commander who had fought in several campaigns in the Mediterranean, including the battle of Lepanto in 1571 and the conquest of Tunisia in 1574. He was later promoted as member of the Council of War. He participated actively in the meetings of the Council of War to plan the Armada expedition of 1588 although he himself did not participate in the campaign, see Anes et al. 2009-2013, 416-18.

under Cardona's authority.[2] Immediate action was required, as the cutting and gathering of timber for the new galleons had to start immediately since December and January were the months of the felling season.[3] This urge reflected perfectly the need of the Spanish crown for new galleons. The King provided an initial budget of 150,000 ducats for the construction of the galleons: 100,000 ducats to construct the hulls, and 50,000 ducats to outfit the galleons (excluding artillery). The ships' rigging and spars were to be purchased through contracts (*asientos*) with private suppliers, and the construction of the galleons would be distributed between the shipyards of Cuatro Villas (Cantabria), Biscay, and Guipúzcoa (Basque Country) (Figure 1).[4]

The committee of shipwrights

The initial meeting of the committee took place in Santander in December 1588, and was attended by 25 shipwrights and ship owners from the provinces of Cuatro Villas (Cantabria), Biscay, and Guipúzcoa whose attendance was requested by Cardona, following Barros's advice.[5] Cristóbal de Barros arrived in Santander expecting to be put

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[2] Born in Huelva (Andalusia, Spain), Agustín de Ojeda became one of the most prolific shipbuilders of his time, building more than 30 galleons for the Spanish crown between 1589 and 1617. He began serving in the Indies run with the *Adelantado* Pedro Menéndez de Avilés around 1566, took part in the Battle of Terceira in 1582, and in the Great Armada sent against England in 1588, see AGS GYM Leg. 459 doc. 95, cited in Goodman 1997, 125; also see Vicente Maroto 2006, 311-43
[3] AGS GYM Leg. 244 doc. 267.
[4] AGS GYM Leg. 244 doc. 267; AGS GYM Leg. 244 doc. 268.
[5] AGS GYM Leg. 244 doc. 74; Cristóbal de Barros became the superintendent of forest and plantations of the regions of Galicia, Asturias, Cuatro Villas (Cantabria), Biscay and Gipuzcoa between 1574 and 1596, although he became inactive in 1592 after he was appointed as purveyor-general (*proveedor*) of the Indies escort fleet, see Goodman 1997, 70, 275; Phillip II also appointed Cristobal de Barros as official surveyor in 1590 since Barros had been gauging ships' volumes on the Cantabrian coast on behalf of the crown since 1563. Additionally, that year Barros was charged with supervising the loans given to private shipbuilders to build vessels that could serve in the Armadas of the Spanish crown. AGS GYM Leg. 71

in charge of the construction of the new galleons, due to his previous construction experience as well as the reputed quality of his galleons. Cardona, however, had serious doubts about Barros's expertise in ship design because he lacked sailing experience and was unfamiliar with performance of ships at sea since he had only seen them in port. Moreover, people who had sailed on Barros's galleons pointed out several design flaws, such as their deep draft. The committee met to discuss the most suitable dimensions, deck configurations, and tonnages for the new galleons. All the experts but Barros agreed upon an initial design proposal that was sent to the King for evaluation and approval.[6]

The shipyards

The choice of shipyards for the construction of the new galleons was another important issue discussed during the meeting in the city of Santander, in Cuatro Villas (Figure 1). Barros had already advised the King about the advantages and disadvantages of the shipyards located in the provinces suggested in the King's initial instructions. According to Barros, in Cuatro Villas (Cantabria) there were abundant forests to supply wood for the construction of the galleons. However, the forests were far from rivers and roads, which made it difficult to transport the timber to the shipyard. Moreover, many of the roads were impassible in winter due to bad weather. Along with timber, metal

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doc. 227 and AGS CMC 3a Leg. 3532 n. 3, in Casado Soto 1988, 84, 103; He was also responsible for the design and construction of a series of nine galleons in 1581. AGS GYM Leg. 121 doc. 76, also in Casado Soto 1988, 149.

[6] AGS GYM Leg. 244 doc. 74.

fastener availability had to be considered. The shipyard of Guarnizo in Cuatro Villas was equipped with a forge to make the metal fasteners needed in the construction of the galleons; however, Guarnizo would require additional workers to be brought in from Bilbao and San Sebastián (Figure 6). In comparison, in the province of Biscay there were several shipyards with significant capability to forge metal fasteners; however, costs were higher in the province of Biscay than in the province of Guipúzcoa. Another down side was the limited supply of timber due to a lack of forests near the Biscayan shipyards. Also, the Portugalete sandbar made the entrance to the inlet of Bilbao very dangerous for ships (Figure 7).

Figure 6. Location of Guarnizo and Santander in Cuatro Villas (Cantabria) (modified from Google Earth Pro satellite maps).

Figure 7. Location of Portugalete in the inlet of Bilbao (Biscay) (modified from Google Earth Pro satellite maps).

Barros believed that the best choice was building the 12 galleons in San Sebastián and Pasajes, in the province of Guipúzcoa, where the forests were close to the shipyards and, therefore, the construction would be faster and cheaper. In Guipúzcoa there was also an abundant workforce, and local blacksmiths could deliver metal fasteners, anchors, and other metal supplies directly to the shipyards (Figure 8). Building the 12 galleons in a single shipyard would also facilitate the supervision of the work to ensure the quality of all 12 ships, and to coordinate their launching with the spring tides.[7]

[7] AGS GYM Leg. 264 doc. 21.

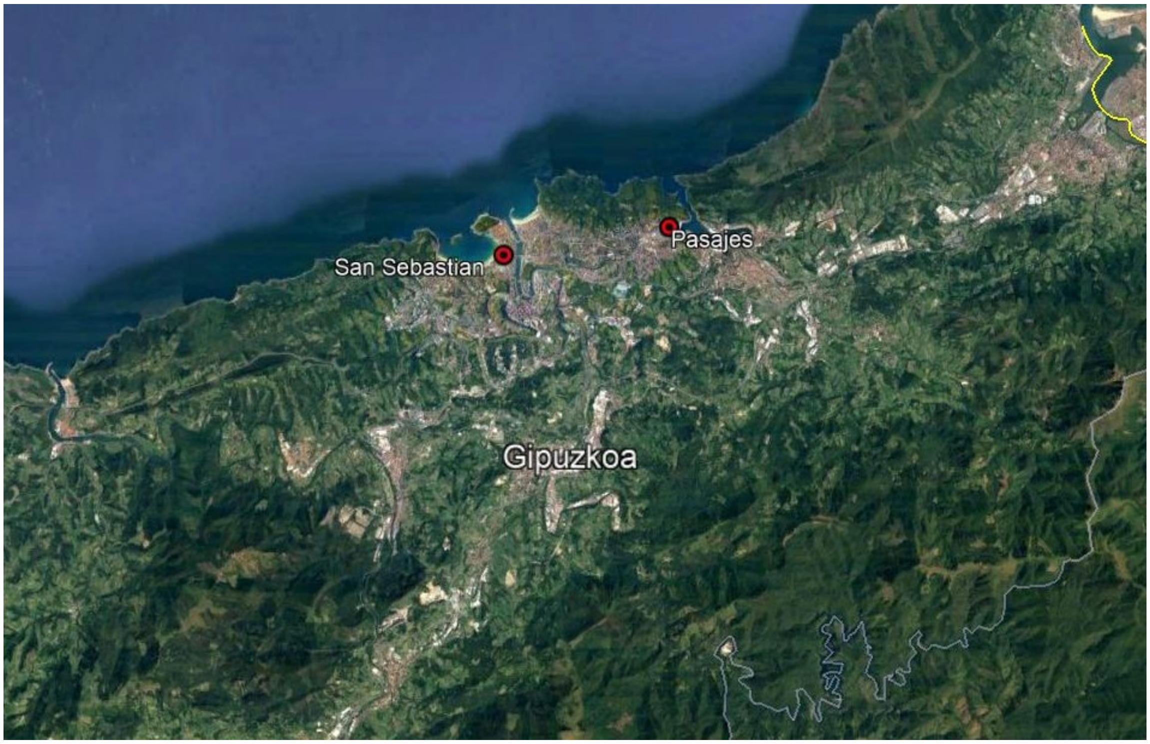

Figure 8. Pasajes and San Sebastián in Gipuzcoa (modified from Google Earth Pro satellite maps).

After consulting all the experts gathered in Santander, however, Cardona rejected Barros's suggestion and decided to build five galleons in the shipyards of San Sebastián and Pasajes (Guipúzcoa), one of 800 tons, one of 600 tons, and three of 500 tons; four galleons in Deusto (Biscay), one of 800 tons, two of 600 tons, and one of 500 tons; and three in Guarnizo (Cuatro Villas), two of 800 tons and one of 600 tons.[8] His decision was based on reports given by the experts regarding the condition of the lands and forests between Santander and Guipúzcoa. Cardona also considered the types of wood available, the logistics needed for the transport of wood to the shipyards, and other

[8] AGS GYM Leg. 244 doc. 87; AGS GYM Leg. 244 doc. 264.

difficulties that could either delay or increase the cost of construction of the galleons. Cardona was also concerned that building all the galleons in one shipyard would exhaust the timber resources of that region, preventing the local people from continuing to build ships for their living.[9]

Cristóbal de Barros and the construction of the Twelve Apostles

At the beginning of January, 1589, Cardona offered Barros first choice between the shipyards of Deusto in Biscay and San Sebastián in Guipúzcoa to build the galleons, and Ojeda would then supervise the construction in the shipyard not chosen by Barros. Cardona was also to designate a payer (*pagador*) to manage the money for the construction, and he would also become an official of the inspector (*veedor*) to supervise the purchase of timber and other construction materials through contracts (*asientos*) with the suppliers.[10] After Barros chose the shipyard of Deusto near Bilbao (Biscay), Cardona sent him the commission for the construction of the galleons.[11]

According to the commission, Barros was to have full authority over the construction of the galleons in Deusto, to ensure they were built rapidly following the technical specifications he would be given. Barros would select the foremen (*sobrestantes*) who he considered most suitable for the work to assist him with the construction tasks. However, all the materials for the construction of the galleons,

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[9] AGS GYM Leg. 244 doc. 87; AGS GYM Leg. 244 doc. 74.
[10] AGS GYM Leg. 244 doc. 87; AGS GYM Leg. 244 doc. 74.
[11] AGS GYM Leg. 244 doc. 87.

especially the timber, had to be purchased with the intervention of a chief magistrate (*justicia*) and an official of the general inspector of the Navy (*veedor general de la armada*). The priority was to purchase wood already cut to build other vessels, and to pay fairly according to the valuation (*tasación*) estimated by Barros. If it became necessary to enter a forest to cut timber, Barros was to be accompanied and supervised by the mayor (*corregidor*) of Biscay, his deputy (*teniente*) or even the chief magistrate (*justicia*) in whose jurisdiction the forests were located. The timber would be purchased before cutting. The same approval of payment was to apply to the other construction materials such as metal fasteners (*clavazón*), pitch (*brea*), oakum (*estopa*), supplies (*pertrechos*), and victuals (*bastimentos*). Master carpenters, caulkers, blacksmiths, sailors, messengers, and other workers would receive decent wages to encourage them to work in the construction of the galleons. Carts, animals, boats, and workers used for the transportation of construction materials to the shipyards would be hired and paid fairly with the intervention of the chief magistrate (*justicia*) and official of the inspector (*veedor*). Cardona also ordered that the mayors (*corregidores*) and chief magistrates (*justicias*) obey Barros in relation to the construction of the galleons, although the construction expenditure was to be supervised by the official of the general inspector (*veedor general*).[12]

After review of the commission from Cardona, however, Barros declined accepting supervising the construction of the galleons in Deusto.[13] In Barros's opinion,

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[12] AGS GYM Leg. 244 doc. 88.
[13] AGS GYM Leg. 244 doc. 266; AGS GYM Leg. 244 doc. 74.

the terms that Cardona proposed to purchase the materials, especially the wood, would unnecessarily delay the completion of the galleons, and increase their cost.[14] Cardona explained to Barros that these conditions were intended to prevent complaints from the owners of the forests, who might object to workers entering their properties to cut timber for the galleons. In fact, such complaints had been made about Barros's behavior during the construction of the previous series of galleons in the Guarnizo shipyard. Cardona had specified the supervision and intervention of the chief magistrates (*corregidores*) to prevent any abuse in this respect.[15]

Barros also refused to accept any authority or supervision over his work, despite this being the orders of the King, as pointed out to him by Cardona.[16] Barros felt he was not being trusted if Cardona and other officials were to supervise his work and his purchases of construction materials. Nevertheless, while the King made a decision on the situation, Barros agreed to go to Biscay to begin the felling of timber in order not to delay the construction of the galleons.[17] Shortly after his arrival, however, he asked the King to be excused from his duty even though the carpenters were already marking the trees to be felled.[18]

The resignation of Barros forced Cardona to modify the assignments for the construction of the galleons, but not the selection of shipyards. He put Agustín de Ojeda in charge of the construction of the galleons in Bilbao, while the four galleons in San

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[14] AGS GYM Leg. 244 doc. 266.
[15] AGS GYM Leg. 244 doc. 74.
[16] AGS GYM Leg. 244 doc. 74.
[17] AGS GYM Leg. 244 doc. 264.
[18] AGS GYM Leg. 244 doc. 74.

Sebastián were assigned to Francisco de Arriola, and the construction in Guarnizo was given to Hernando de la Riva Herrera.[19] Despite the difficulties to obtain construction materials in Santander due to the refitting of the Armada, Riva Herrera accepted the commission to build four galleons: two large ones, one medium-sized one, and one small one. Although the felling season had almost ended, Riva Herrera managed to gather more than 100 sawyers to fashion the ships' main timbers and the planking for the hull and decks.[20] Agustín de Ojeda departed for Bilbao as soon as Cardona ordered him to build four galleons, although he still ignored the definitive dimensions determined for the vessels. In any case, he intended to do his best to build strong galleons at a moderate cost.[21] But when Ojeda arrived in Bilbao he realized that 112 carpenters had been sent to Santander for the construction of the galleons and the refitting of the Armada vessels in Guarnizo. Despite this inconvenience, Ojeda managed to find 40 carpenters in Bilbao, and began felling trees as fast as he could while the waning moon lasted.[22] The payer (*pagador*) also arrived with 6,000 ducats to begin the construction. The money was to be used to pay the wages of carpenters, to buy the wood from owners of the forests, and to sign the contracts (*asientos*) for construction of the galleons.[23] Meanwhile, the King sent

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[19] AGS GYM Leg. 244 doc. 74; AGS GYM Leg. 347 doc. 213; Hernando de la Riva Herrera became the successor of Barros as superintend of forests and plantation of the regions of Asturias and Cuatro Villas (Cantabria) in northern Spain between 1598 and 1605, see AGS GYM Leg. 515 doc. 49, in Goodman 1997, 73, 262.
[20] AGS GYM Leg. 244 doc. 92.
[21] AGS GYM Leg. 244 doc. 37.
22 In 1575, Escalante (1985, 37) indicated that the wood used for shipbuilding had to be cut during the waning moon because it was when the trees were less humid and in an optimal condition. According to Goodman (1997, 110), this was a tradition started by Hesiod in his *Works and Days* in which he recommended the cutting of timber for shipbuilding during the waning moon. However, the most influential work was probably Pliny's *Natural History*.
[23] AGS GYM Leg. 244 doc. 38; AGS GYM Leg 244 doc. 44.

the initial design report to be examined by independent consultants in the Court of Madrid before returning it to Cardona for modification. While awaiting the report, the King advised Cardona to continue with the preparations for construction, including the felling of trees and the gathering of construction materials, regardless of any revision to the galleons' original design.[24]

The final distribution of the galleons and shipyards

Immediately following Cardona's distribution between shipyards of the construction of the galleons, a problem arose in Guipúzcoa. The inhabitants of the town of Rentería refused to allow felling trees from their forests for building the new galleons. They argued that they had invested a great deal of time and effort in planting and protecting the trees, and now wanted to use the wood to build and sell their own ships.[25] Francisco de Arriola warned Cardona that the refusal of the inhabitants of Rentería might delay the construction of the galleons, perhaps even preventing their completion. Arriola also reported that it would be impossible to guarantee the safety of the vessels under construction in San Sebastian should the English attack the shipyards to burn them. Based on these two issues in Guipúzcoa, Cardona decided to distribute the construction of the 12 galleons between Bilbao and Santander, building six in each shipyard (Table 5).[26] It should be noted that, despite the new shipyard allocation,

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[24] AGS GYM Leg. 264 doc. 17.
[25] AGS GYM Leg. 244 doc. 30.
[26] AGS GYM Leg. 244 doc. 85.

preparations for construction had continued according to plan, and master shipwright Pedro de Busturria, who was in Santander working on refitting the Armada vessels, had already prepared a list with the dimensions of the masts and yards for the new galleons.[27]

Table 5. Construction of the Twelve Apostles.

Shipyard	Shipbuilder	Galleon	Keel laying	Launch	Commissioned
Guarnizo (Cuatro Villas)	Riva Herrera	*San Pedro*	February 14, 1589	October 12, 1589	April 1592
Guarnizo (Cuatro Villas)	Riva Herrera	*San Andrés*	-	November 23, 1589	May 30, 1591
Guarnizo (Cuatro Villas)	Riva Herrera	*San Pablo*	March 27, 1589	February 4, 1590	June 1, 1591
Guarnizo (Cuatro Villas)	Riva Herrera	*Santiago*	-	March 7, 1590	April 1592
Guarnizo (Cuatro Villas)	Riva Herrera	*Santo Tomás*	-	May 1, 1590	June 1, 1591
Guarnizo (Cuatro Villas)	Riva Herrera	*San Juan*	-	Late May – Early June, 1590	April 1592
Deusto (Biscay)	Ojeda	*San Matías*	March 1589	October 23, 1589	Summer 1592
Deusto (Biscay)	Ojeda	*San Bartolomé*		November 21, 1589	Summer 1592
Deusto (Biscay)	Ojeda	*San Simón*		December 7, 1589	June 22, 1591
Deusto (Biscay)	Ojeda	*San Tadeo*		January 18, 1590	Summer 1592
Deusto (Biscay)	Ojeda	*San Felipe*		February 20, 1590	June 22, 1591
Deusto (Biscay)	Ojeda	*San Bernabé*	-	March 22, 1590	June 21, 1591

Ojeda and Riva Herrera both accepted the commission to build two more galleons each, although Ojeda had been compelled to send master shipwright Juan de Uriarte with 50 carpenters to Santander to work in Guarnizo. Ojeda had managed to

[27] AGS GYM Leg. 244 doc. 70.

gather 400 workers in Deusto, and 150 carpenters were already cutting and sawing wood for the galleons. However, the poor condition of the roads due to winter weather made it difficult to transport the wood to the shipyard. In addition, carpentry wages were higher in Bilbao than in other parts of Biscay, and that would increase the cost of the construction of the galleons.[28] In Guarnizo, meanwhile, Riva Herrera was trying to cut, transport, and stockpile all the wood he needed for the construction of the galleons as fast as possible.[29]

While preparatory work was underway in the shipyards, Barros raised new concerns to the King about the design that the committee of shipwrights had settled for the new galleons. He informed the King that the new galleons may have been conceived as merchant vessels, and with larger tonnages than ordered initially. It seems likely that the main reason for the conflict between Barros and Cardona was related to the struggle for control of Spanish naval design and shipbuilding between the military and the Crown's public servants. Barros thought that control of the design and construction of the galleons should be the responsibility of the contractors until the ships were completed and delivered to Navy officials. This could well have been the real reason behind Barros's refusal to accept Cardona's authority regarding the construction of the new vessels.[30]

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[28] In the town of Lequeitio, on the east of Biscay, a master carpenter earned 4 *reales* while the carpenters were paid 3 and half *reales*. In Bilbao, the carpenters' wages were 4 *reales* and a quarter, and even higher for the master carpenters, see AGS GYM Leg. 244 doc. 39.
[29] AGS GYM Leg. 244 doc. 39; AGS GYM Leg. 244 doc. 217.
[30] AGS GYM Leg. 244 doc. 269.

In February, 1589, Philip II again ordered Cardona to place Barros in charge of the construction of the galleons in Bilbao, while concurring that Ojeda could work on the refitting of the Armada vessels in Santander because of his previous experience. Cardona was skeptical regarding this plan because Barros refused to work under any supervision. Moreover, Cardona believed that if the galleons were built according to Barros's design, the ships would be useless.[31] Despite his reservations, Cardona tried once more to convince Barros to accept the commission for the construction of the galleons in Bilbao.[32] However, no changes were made regarding shipyard assignments or the supervisory arrangement over people placed in charge of the construction of the galleons, and Barros again refused to accept the project.

Building the Twelve Apostles

In spite of the uncertainties that still existed regarding the final dimensions of the new galleons, the construction of the ships had already begun in the shipyards of Deusto (Bilbao) and Guarnizo (Cuatro Villas). However, Riva Herrera complained to the King when he was directed to build two more galleons in Guarnizo, because the entire region was already exhausted from the efforts made to refit the Armada ships. The obligation to build two more galleons in Guarnizo exerted additional pressure on resources and people of the region. Riva Herrera intended to build one galleon at a time to avoid the carpenters interfering with each other's work, especially in relation to the distribution of

[31] AGS GYM Leg. 245 doc. 2.
[32] AGS GYM Leg. 245 doc. 3.

the wood available for construction. In Riva Herrera's opinion, there was no need to complete all the galleons at the same time, because only one ship could be launched every 15 days due to the schedule of the spring tides. According to Cardona, the twelve new galleons were to be named after Jesus's Apostles, and Riva Herrera intended to lay the keel of *San Pedro*, one of the largest, on February 14, 1589 (Table 5).[33]

It must be noted that the royal treasury was virtually exhausted due to the cost of the Armada of 1588, the cost of which amounted to around 10 million ducats.[34] Despite the initial allocation by the crown of 150,000 ducats for the construction and outfitting of the new galleons, the shortage of funds was to become a constant threat to the completion of the galleons. Both Riva Herrera and Ojeda would have to deal with this issue in order to pay the wages of the workers and to purchase the construction materials. By February of 1589, Riva Herrera had already spent half of the 20,000 ducats that the King had sent him to begin the construction of the six galleons. Riva Herrera complained that building the galleons in Guarnizo was more expensive than in Deusto because he had to pay for the transport of both construction materials and workers to the shipyard; just transporting the carpenters, metal fasteners, and other supplies from Bilbao to Guarnizo had cost 3,000 ducats. In Deusto, on the other hand, the suppliers delivered all the materials directly to the shipyard, and the majority of the carpenters lived in the province of Biscay. Riva Herrera intended to gather more than 400 carpenters in Guarnizo, although if they were not paid every Sunday they could leave the

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[33] AGS GYM Leg. 245 doc. 32.
[34] Goodman 1997, 8.

shipyard immediately, and any delays caused by an interruption in pay could ultimately delay the construction of the galleons.[35]

Things did not look better in Deusto, where Ojeda also needed funds to pay for construction materials according to the contracts (*asientos*) signed with the suppliers.[36] Work would also stop in Deusto if Ojeda had no money to pay workers' salaries.[37] Despite funding challenges, Ojeda managed to prepare four keels, four sternposts, and 12 timbers for the stems of the galleons to be laid during the second week of February.[38] However, Ojeda warned Cardona that he had yet to receive the report with the final dimensions for the galleons.[39] The main timbers cut and shaped for the two additional galleons turned out to be flawed; therefore, he ordered two additional sets. Ojeda kept stockpiling wood in the shipyard for the construction of the galleons, while more wood was on the way from nearby forests. All this wood had already cost 9,000 ducats, and the wages of the carriers and carpenters amounted to an additional 800 to 900 ducats per month.[40] Ojeda recommended bringing spar timbers to make the masts and yards for the galleons from Germany or Lisbon (Portugal) because the spars available in Bilbao did not have the appropriate dimensions.[41]

The final dimensions of the new galleons remained unclear due to Barros's criticism of the original proposal. Barros even sent his own design to the King, which

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[35] AGS GYM Leg. 245 doc. 31; AGS GYM Leg. 245 doc. 32.
[36] AGS GYM Leg. 245 doc. 88; AGS GYM Leg. 245 doc. 75.
[37] AGS GYM Leg. 245 doc. 5.
[38] AGS GYM Leg. 245 doc. 88; AGS GYM Leg. 245 doc. 76.
[39] AGS GYM Leg. 245 doc. 75.
[40] AGS GYM Leg. 246 doc. 76.
[41] AGS GYM Leg. 245 doc. 88.

Phillip II forwarded to Cardona for discussion by the committee of shipwrights.[42] The committee met again in Santander, but decided to maintain the original design with only minor variations. An extensive, detailed report was sent to the King, who accepted Cardona's explanations, and approved the construction of the galleons according to the design of the committee.[43]

At the beginning of March, work stopped for several days on the galleons in Guarnizo, when the salaries of workers could not be paid. Cardona had to borrow money and give it to the payer (*pagador*) of the construction to fulfill payment obligations.[44] The construction of the galleons then continued according to the finalized set of dimensions provided to Riva Herrera by Cardona. Most of the framing, and even the mast step, of *San Pedro* were already in place, and the dimensions of the main floor timber of *San Andrés* had been decided, and its stem, sternpost, and several frames had been assembled. The construction sequence of the galleons was based on their launching schedule. Riva Herrera also had to borrow money to pay the wages of carpenters, sawyers, blacksmiths, and timber carriers. In addition to salaries, he had to pay for the food of the carpenters who arrived from Biscay in order to entice them to stay at the shipyard.[45] Despite these financial problems, Riva Herrera still expected to lay the keel of *San Pablo*, another large galleon, on March 27 (Table 5).[46] The safety of the galleons under construction was becoming a concern for Cardona, as news began to arrive from

[42] See document AGS GYM Leg. 264 doc. 24 included in AGS GYM Leg. 264 doc. 23.
[43] AGS GYM Leg. 245 doc. 7; AGS GYM Leg. 245 doc. 11.
[44] AGS GYM Leg. 246 doc. 2.
[45] AGS GYM Leg. 246 doc. 15.
[46] AGS GYM Leg. 249 doc. 16.

England regarding preparations for a naval expedition against Spain. Despite Guarnizo being situated in the bay of Santander, which had a narrow entrance facilitating its defense, Cardona recommended additional defensive measures.[47]

The keels of five galleons, with their stems and sternposts, were laid in Deusto, and carpenters began assembling the frames (Table 5). Ojeda expected to lay the keel of the last galleon during March. As with Riva Herrera, Ojeda was also forced to borrow money to pay salaries and to buy food in order to continue with the construction of the galleons. The spars, rigging, sails, and cables were to be purchased through contracts (*asientos*) from private suppliers. Ojeda recommended importing spars from Lisbon or Germany because they were cheaper and of better quality than the oak available in Biscay, whose heavy weight could damage the hulls.[48] Even the Duke of Medina Sidonia was asked to send spars from Cadiz or Seville to Santander; Medina Sidonia also suggested contacting merchants in Lisbon or Germany to bring them from Norway, which would be both cheaper and safer.[49]

The shortage of money continued in April, and Ojeda had to borrow 3,500 ducats to pay the wages of the carpenters, despite already owing 10,000 ducats to the suppliers of wood and metal fasteners, who also demanded to be paid. The priority, however, was to pay the wages of the workers, because without money they would be unable to buy food, and could be tempted to leave the shipyard to return to their homes.[50] That would

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[47] AGS GYM Leg. 246 doc. 5.
[48] AGS GYM Leg. 246 doc. 90.
[49] AGS GYM Leg. 246 doc. 153.
[50] AGS GYM Leg. 247 doc. 84; AGS GYM Leg. 247 doc. 87.

result in an unnecessary halt of construction during the best part of the year to work in the shipyard (based on temperate weather and longer hours of daylight).[51] Despite all these inconveniences, work continued in Deusto, and the third row of futtocks began to be assembled in some of the galleons.[52] In Guarnizo, Riva Herrera was also expecting to receive more money to pay for construction expenses. He owed 12,000 ducats, although he had managed to saw and shape 80,000 cubits (*codos*) of planking.[53]

In May, the Deusto carpenters threatened to stop construction because they were owed 60 days of wages; Ojeda managed to convince them to keep working, saying that the King was about to remedy the situation. Despite this threat, work continued steadily due to the good weather, although if not paid, workers might stop any time.[54] Meanwhile in Guarnizo there were four galleons under construction. The working of *San Pedro* was almost completed, and the carpenters were adding the last strake of hull planking. In Riva Herrera's opinion, *San Pedro* was the largest and strongest vessel he had ever built, due to the quality of the wood employed for its construction. Unfortunately, the lack of money prevented him from starting the construction of the fifth galleon, and he was not able to take advantage of longer daylight hours to bring forward the construction of the other galleons. Moreover, the good weather also allowed carts to carry more timber to the shipyard; a cart pulled by four oxen in good weather could carry the same amount of

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[51] AGS GYM Leg. 247 doc. 85.
[52] AGS GYM Leg. 247 doc. 87.
[53] AGS GYM Leg. 247 doc. 25; One *codo* of planking *8 en codo* contained about 0.0158 cubic meters of wood. Therefore 80,000 cubits of wood equaled approximately to 1,264 cubic meters of wood, see Loewen 2007, 3:19.
[54] AGS GYM Leg. 248 doc. 50; AGS GYM Leg. 248 doc. 49; AGS GYM Leg. 248 doc. 51.

wood as one pulled by eight oxen in winter. Riva Herrera informed the King that, during the last five months, he had completed construction work that was worth 35,000 ducats, although he had only received 10,000 ducats. He pleaded with the King to allocate sufficient funds for the construction of the galleons, and to pay the payer (*pagador*), the inspector (*veedor*), and the purveyor (*proveedor*) a salary for their work in Guarnizo.[55]

Since the masts and yards for the galleons were to be brought from abroad, it was necessary to plan their purchase in advance to ensure they would arrive on time to Guarnizo and Deusto, avoiding any delay in the completion of the galleons.[56] The purveyor (*proveedor*) Bernabé de Pedroso made a deal with Julian de Isasti, a merchant from Rentería (Guipúzcoa), to bring the spars from Flanders.[57] Pedroso gave Isasti a list with the quantity and dimensions of the spars and rigging required for the twelve new galleons.[58] However, the contract could not be signed until the King sanctioned the deal and provided a deposit to ratify it. This situation gave Cardona a cause for concern because it might delay the delivery of the materials and, therefore, the completion of the galleons.[59]

In June, rumors reached Spain that England was constructing new warships. This exerted even more pressure regarding the completion of the Apostles.[60] Despite repeated pleas to the King, Ojeda had not received any funds for the past three months, and he

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[55] AGS GYM Leg. 248 doc. 26.
[56] AGS GYM Leg. 248 doc. 7.
[57] AGS GYM Leg. 248 doc. 7.
[58] AGS GYM Leg. 249 doc. 259.
[59] AGS GYM Leg. 248 doc. 7.
[60] AGS GYM Leg. 249 doc. 51.

was forced to borrow more money to buy wheat to feed the workers, which kept construction going. He already owed 23,000 ducats, which included the wages for 65 days of work, and 14,000 ducats in construction materials. However, the wheat was almost gone, and the suppliers refused to provide more construction materials without being paid. Work at Deusto could stop at any time unless the King took immediate action to remedy the situation.

Since each galleon required about two months of additional carpentry work after its launching, Ojeda intended to launch all six galleons by January 1590 in order to have them ready to sail by May of 1590.[61] However, it would be impossible to keep this schedule without additional costs if construction stopped at Deusto due to the lack of money.[62] The purveyor (*proveedor*) Baltasar de Lezama also feared that the carpenters could enroll in the fishing fleets bound for Terranova if they were not paid regularly.[63] Riva Herrera was having similar problems in Guarnizo where, unless the King sent money, he would be unable to launch four galleons in September as he had initially planned.[64] Fortunately, just as the situation seemed most critical, Cardona received 50,000 ducats at the end of June, sent by the King to be distributed between Ojeda and Riva Herrera.[65]

Cardona gave a deposit of 8,000 ducats to Julian de Isasti in July to guarantee the delivery of the spars and rigging for the new galleons, and Isasti signed a contract with a

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[61] AGS GYM Leg. 249 doc. 58; AGS GYM Leg. 249 doc. 59.
[62] AGS GYM Leg. 249 doc. 58; AGS GYM Leg. 249 doc. 59.
[63] AGS GYM Leg. 249 doc. 60.
[64] AGS GYM Leg. 249 doc. 65.
[65] AGS GYM Leg. 249 doc. 16.

Flemish merchant to provide the spars. Ojeda used the 21,000 ducats that he received to pay the arrears to the carpenters, and to clear the most urgent debts with the suppliers of construction materials. He also intended to stockpile as much wood as possible in the shipyard before the end of the summer, because September rain would make road conditions difficult for wood transport to the shipyard.[66] After Ojeda fulfilled the most urgent payments, he had enough money left to pay wages for only eight days of work. His plan was to launch three galleons between the end of September and October 20. However, he needed rigging and cables to launch, then moor the galleons, but according to Isasti, these materials would not be available until December. Therefore, Ojeda suggested making the needed cordage in Deusto, to be able to complete the galleons in the intended time frame. He expected to launch the remaining three galleons at the end of December 1589.[67] The safety of the galleons under construction was becoming a serious concern as the work progressed. When Alvaro de Bazán wrote to the King praising the quality of the new galleons, he also suggested assigning soldiers to guard the ships in the shipyards in case of an English attack.[68]

In September, the King ordered Juan del Águila, the *Condestable* of *Castilla*, to send 300 soldiers to Santander to guard the galleons. However, Riva Herrera said that it was impossible to accommodate that many soldiers in the shipyard; he thought that 30 soldiers and armed workers should be enough to patrol the bay on a boat, and to protect

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[66] AGS GYM Leg. 250 doc. 79.
[67] AGS GYM Leg. 250 doc. 80.
[68] AGS GYM Leg. 250 doc. 26.

the galleons. Therefore, he asked for 200 harquebuses, gunpowder, match cord, and lead shot to arm the workers.[69] At the end, the *Condestable* dispatched only 30 soldiers who arrived in Santander at the end of the month, even though he believed that just two or three veteran soldiers should have been sufficient to train the workers to protect the galleons.[70] Riva Herrera wanted to launch *San Pedro* in October, and the next galleon in November, if the clement weather lasted. There were 400 workers in the shipyard, but Riva Herrera was concerned that they could leave any time due to the constant delays in paying their wages.[71]

Agustín de Ojeda asked the King to be paid a salary for his work. He had already invested more than 1,100 ducats of his own money in the construction of the galleons, and no one wanted to lend him more money to continue the work.[72] Ojeda was able to pay part of the arrears that he owed to the carpenters and blacksmiths thanks to 4,000 ducats that Baltasar de Lezama lent him following the King's orders. However, he still had many pending payments because there were more than 500 workers in the shipyard, including carpenters and caulkers. Despite the financial challenges, Ojeda intended to launch one galleon in early October, and he asked the King to send him money immediately to continue the work. The galleons needed to be caulked during the next month and a half, before the winter rains began, but there were no more than 120 caulkers in the shipyard due to a shortage of caulkers in Biscay.[73]

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[69] AGS GYM Leg. 251 doc. 76.
[70] AGS GYM Leg. 251 doc. 65; AGS GYM Leg. 251 doc. 77; AGS GYM Leg. 251 doc. 75.
[71] AGS GYM Leg. 251 doc. 48.
[72] AGS GYM Leg. 251 doc. 34.
[73] AGS GYM Leg. 251 doc. 35.

The sudden death of Julian de Isasti created much uncertainty regarding the delivery of the rigging for the galleons. Riva Herrera insisted that Isasti's heirs and guarantors should be responsible for fulfilling the contract.[74] He recommended confirmation of the terms of the deal that Isasti had made with the Flemish merchants for provisioning of the rigging in order to ensure their delivery would occur without delay.[75] Riva Herrera urgently needed cables and tackle to launch the galleon *San Pedro,* but he lacked the funds to purchase them. Therefore, he intended to bring some rigging from Bilbao, and to borrow cables and anchors from the store keeper of the Navy (*tenedor*).[76]

In October, the King ordered the provision of an additional 50,000 ducats for the construction of the galleons. Ojeda was to receive 25,000 ducats, although that amount was insufficient to pay all the debts and overdue payments. He owed money for the contracts (*asientos*) signed with the suppliers of metal fasteners (*clavazón*), hemp (*cáñamo*), tar (*alquitrán*), lead (*plomo*), tallow (*sebo*), and other materials including timber, all of whom he had promised to pay as soon as he received any funds from the King. Moreover, he also had to pay the arrears he owed to the carpenters and rest of the workers in the shipyard. Thus, he suggested that the King order the disbursement of more funds to continue with the construction of the galleons. The shortage of caulkers in Biscay also made it difficult for Ojeda to prepare the galleons for launching. Many caulkers had been sent to Guarnizo, and Ojeda was able to caulk only the hull of one

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[74] AGS GYM Leg. 251 doc. 48.
[75] AGS GYM Leg. 251 doc. 49.
[76] AGS GYM Leg. 251 doc. 54.

large galleon to be launched in October. However, he had two more galleons in the shipyard ready for caulking, and he intended to launch them in November, although there were not enough rigging supplies in Deusto to launch and moor the galleons. For this reason, Ojeda proposed to the King to use the 4,000 ducats owed to Lezama to purchase ropes and cables for the launching.

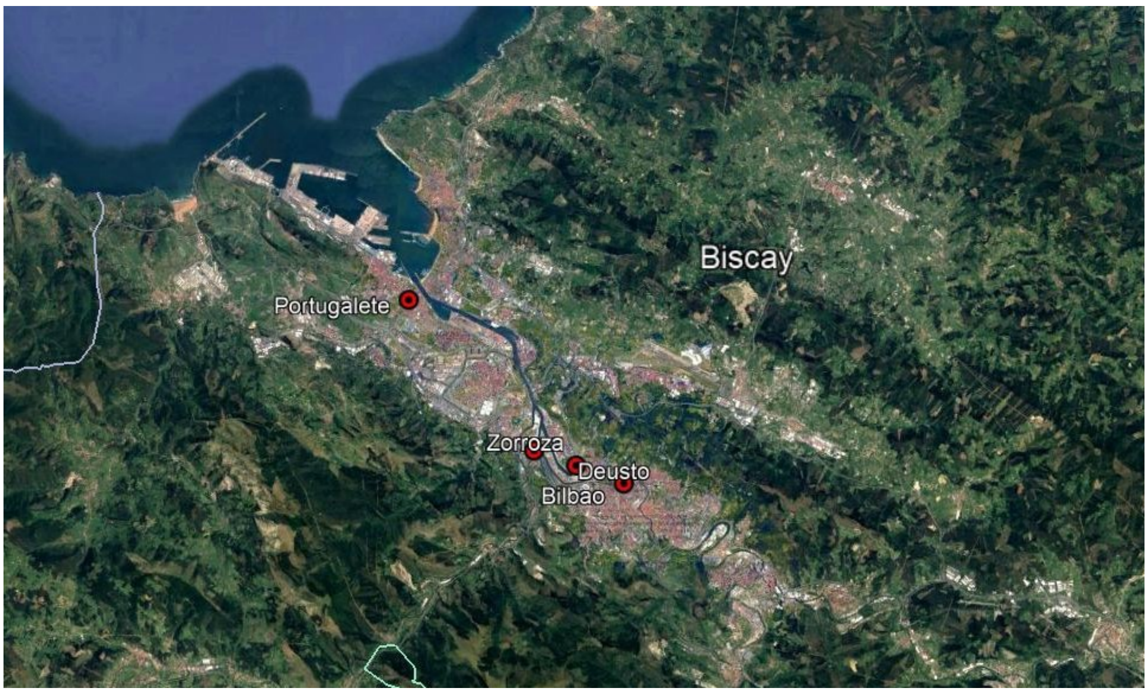

Figure 9. Location of Zorroza in Biscay (modified from Google Earth Pro satellite maps).

In addition to rigging, the galleons also needed canvas for the sails. The best quality canvas was produced in the town of Pondavid (Pont-Aven)[77] in Brittany (France). Its thickness and strength made it the most suitable cloth for sails to propel

[77] Emmer and Gaastra 1996, 65.

large galleons such as the ones under construction. However, it was forbidden to take sailcloth out of France due to the war, and it was necessary to plan in advance how to purchase and bring the canvas to Spain.[78] Ojeda estimated that the 12 galleons would need a minimum of 900 pieces of sailcloth from Pondavid, 75 per galleon, although additional canvas required for spare sets of main courses and topsails would increase the total amount required to 1,500 pieces. Ojeda decided to approach a merchant in Bilbao who had business connections in France to organize the purchase and transport of the sailcloth to Spain.[79]

Launching the galleons

The *San Matías*, one of the large galleons built in Deusto, was launched without incident on October 23, and moored at the port of Zorroza (Table 5) (Figure 9).[80] Everyone in Deusto was impressed with the quality of the construction of the galleon. At the same time, one of the medium-sized galleons was being caulked, although the shortage of caulkers in the shipyard delayed the completion of the remaining galleons.[81] This situation led Ojeda to ask the King to order all the caulkers in Biscay to go to work in the shipyard, as well as to transfer caulkers from Guarnizo to Deusto. In his opinion, since the Armada vessels were to winter in the port of Pasajes (Guipúzcoa), there was no reason for the caulkers to remain in Santander until the Armada returned in March of the

[78] AGS GYM Leg. 252 doc. 44.
[79] AGS GYM Leg. 347 doc. 142.
[80] AGS GYM Leg. 347 doc. 140.
[81] AGS GYM Leg. 347 doc. 145.

next year.[82] The financial situation was becoming desperate in the shipyard as Ojeda had not yet received any money. He was unable to purchase 600 hundredweights (*quintales*) of rigging brought by a hulk (*urca*) from Hamburg, and Lezama was also asking Ojeda to repay the 4,000 ducat loan he had given him.[83]

The galleon *San Pedro* had been launched in Guarnizo on October 12 (Table 5). The launching was difficult, and *San Pedro* grounded in shallow water for a day because, although Guarnizo was an excellent shipyard to build vessels, it was not well suited for launching large ships.[84] Since there were only five shipwrights working in Guarnizo, the same master shipwright who had built *San Pedro* laid the keel of the sixth galleon. Meanwhile, the galleon *San Andrés* was being planked and caulked because Riva Herrera planned to launch it within 30 days.[85] As soon as *San Pedro* was floating in the water, carpenters began building its upper works.[86] Riva Herrera was very proud of the quality of the galleons that he and Ojeda were building for the royal Armada. In his opinion, the galleons had to be built very carefully to avoid any design or construction flaw, as had happened with the previous series of galleons that Barros built in Guarnizo. According to Riva Herrera, those galleons were not suitable for naval warfare because, once completed, their design flaws could not be rectified.[87] The construction of the galleons in Guarnizo was also experiencing difficulties due to money shortages. Riva

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[82] AGS GYM Leg. 347 doc. 142; AGS GYM Leg. 347 doc. 140.
[83] AGS GYM Leg. 347 doc. 140; AGS GYM Leg. 347 doc. 145; AGS GYM Leg. 347 doc. 142.
[84] AGS GYM Leg. 252 doc. 54; AGS GYM Leg. 252 doc. 49.
[85] AGS GYM Leg. 252 doc. 49.
[86] AGS GYM Leg. 252 doc. 49.
[87] AGS GYM Leg. 252 doc. 54.

Herrera still had to pay for the wood cut in the royal forests, although the prices were lower than the cost of wood bought from private forests. He also had to ensure that the workers received their wages, and he had to pay cash to the suppliers of metal fasteners, otherwise no one would sign a contract (*asiento*) to provide them.[88]

With respect to the provision of rigging, the heirs and guarantors of Julian de Isasti felt they had no obligation to fulfill the contract (*asiento*) because the accountant (*contador*) Francisco de Arriola took back the deposit of 8,000 ducats.[89] Moreover, the Flemish merchants Adrian de Bomene and Juan Verhagen, with whom Isasti signed the contract (*asiento*) to supply the rigging, had only delivered a portion of it.[90] A new agreement was being negotiated with the Flemish merchants to provide the rest of the rigging, including the spars for the new galleons. However, they intended to deliver the rigging in several shipments, and wanted to be paid half of the total cost of the merchandise in advance. In their opinion, it would be quite difficult to find spars for the galleons with the dimensions and thickness specified in the list that Isasti had provided.[91]

Ojeda planned to launch the galleon *San Bartolomé* by mid-November if the good weather lasted.[92] The security of the galleons was becoming a serious concern in Deusto due to the presence of numerous foreigners in the area, particularly the French. General Martín de Bertendona feared that there could be an attempt to burn the galleons under construction. He, therefore, recommended stationing soldiers in the shipyard, as in

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[88] AGS GYM Leg. 252 doc. 49.
[89] AGS GYM Leg. 252 doc. 49.
[90] AGS GYM Leg. 252 doc. 8; AGS GYM Leg. 265 doc. 22.
[91] AGS GYM Leg. 252 doc. 8.
[92] AGS GYM Leg. 253 doc. 34; AGS GYM Leg. 253 doc. 55.

Guarnizo, to protect the vessels from harm.[93] The *San Bartolomé* was finally launched on November 21, and moored in Zorroza with eight cables next to *San Matías* (Table 5). Meanwhile, work continued on the other ships, and Ojeda expected to launch another galleon within 20 days, during the next spring tide. His main concern was not the weather or the tide, but the arrival of masts and yards in time to support the completion and launching of the galleons.[94]

In Guarnizo, Riva Herrera expected to have the galleons ready to sail in June of 1590.[95] *San Andrés*, one of the medium-sized galleons, was launched on November 23, and moored with *San Pedro* (Table 5). Work continued on the other galleons, and the caulking of *San Pablo*, one of the large galleons, had begun, but inclement weather and limited daylight were delaying the work. Riva Herrera did not expect to launch any other galleons soon due to the bad weather and the lack of cables.[96]

The 50,000 ducats sent by the King finally arrived in Santander in November, and 25,000 ducats were immediately sent to Bilbao.[97] Since there was no news about the arrival of the spars, Riva Herrera sent carpenters to the forests near the shipyard to look for oak trees to make the mainmasts, foremasts, and mizzenmasts for the galleons, even if the weight of the oak pieces might damage the hulls. In any case, he still needed pines for the yards and topmasts. The oaks were to be felled in January, during the waning

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93 AGS GYM Leg. 253 doc. 34; AGS GYM Leg. 253 doc. 35.
94 AGS GYM Leg. 253 doc. 39; AGS GYM Leg. 253 doc. 40.
95 AGS GYM Leg. 253 doc. 46.
96 AGS GYM Leg. 253 doc. 46; AGS GYM Leg. 253 doc. 54.
97 AGS GYM Leg. 253 doc. 44.

moon, although there was also the option to try to bring spars from Nantes (France).[98] It should be noted that the use of different types of trees, other than pines, for the masts and yards of the galleons was not uncommon. During the construction of the previous series of galleons in Guarnizo, the ships were initially fitted with beech masts, although they cracked during their voyage to Lisbon, where they were replaced with pine masts.[99]

Ojeda insisted on obtaining the rigging brought in October by the hulk (*urca*) from Hamburg because it was unclear if the Flemish merchants would be able to deliver the rigging and spars needed for the galleons. It seemed possible that the Flemish merchants would be unable to deliver the rigging before the next April. Therefore, Arriola and Riva Herrera began to negotiate with other suppliers to ensure the arrival of the rigging for the launching and outfitting of the galleons as soon as possible.[100]

The third galleon was ready for launching in Deusto at the beginning of December, with the next spring tide. Ojeda expected to be able to launch another in January of 1590, and the remaining two with an interval of 25 days between them. According to Ojeda's calculations, the caulkers (*calafates*) and fasteners (*empernadores*) in Deusto had not missed a single day of work since construction began.[101] Unfortunately, that was not true for the carpenters, who had lost several days of work due to cold and rainy weather in addition to multiple holidays. Fortunately for Ojeda, the fact that the carpenters had not been paid for the last two months prevented them

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[98] AGS GYM Leg. 253 doc. 44.
[99] AGS GYM Leg. 163 doc. Doc. 75, in Casado Soto 1988, 150.
[100] AGS GYM Leg. 253 doc. 46; AGS GYM Leg. 253 doc. 55; AGS GYM Leg. 253 doc. 39; AGS GYM Leg. 253 doc. 54; AGS GYM Leg. 253 doc. 40; AGS GYM Leg. 253 doc. 57.
[101] AGS GYM Leg. 254 doc. 14.

from spending money in gambling and drinking during the holidays.[102] *San Simón*, one of the largest galleons, was finally launched on December 7, while the fourth one was to be in the water by the end of the month (Table 5). In Ojeda's opinion, *San Simón* was one of the best galleons he had built in Deusto, although time was to prove the opposite.[103]

Twenty-four carpenters were working on the three galleons moored in Zorroza; their mooring cables were checked daily by the boatswains (*contramaestre*) and the sailors, and four people armed with harquebuses guarded each galleon at night.[104] Ojeda thought that if the masts and yards for the galleons arrived in January, the galleons would be ready to sail in May of 1590.[105] Riva Herrera also expected to complete the carpentry work of his galleons by May, although he complained that Ojeda was able to build his galleons more rapidly because both materials and workers came from nearby the shipyard, unlike Riva Herrera's situation in Guarnizo.[106] Ojeda finally decided to buy the 600 hundredweights (*quintales*) of rigging of the hulk (*urca*) from Hamburg because they cost less than 5 ducats per *quintal*, and Ojeda asked Riva Herrera to remove that sum from the contract (*asiento*) he signed with Arriola to provide the rigging for the 12 galleons.[107] Therefore, there was no need to sign a new contract (*asientos*) for the

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[102] AGS GYM Leg. 254 doc. 67.
[103] AGS GYM Leg. 254 doc. 15.
[104] AGS GYM Leg. 254 doc. 18.
[105] AGS GYM Leg. 254 doc. 19.
[106] AGS GYM Leg. 254 doc. 52.
[107] AGS GYM Leg. 254 doc. 15; AGS GYM Leg. 254 doc. 16.

rigging from Flemish or German merchants, and no need to purchase poorer quality French cordage.[108]

San Tadeo, the fourth galleon built in Deusto, was launched on January 19, 1590, while the work continued on the final two galleons (Table 5). As usual, Ojeda was running out of funds and asked the King to provide more despite having just received 3,000 ducats to pay for the rigging needed to outfit and moor the galleons. However, he still had to pay the wages he owed to the workers and, in the end, Ojeda was unable to purchase the rigging brought by the hulk (*urca*) from Hamburg.[109]

The carpentry work of the galleons that were in the water in Guarnizo was almost completed. In Riva Herrera's opinion, those galleons would need to be caulked before leaving Guarnizo due to the long time spent in the water. He intended to outfit at least two more galleons with the rigging that he was expecting from Bilbao, although he had no masts. In fact, he also needed bolts (*cabillas*), mastheads (*tamboretes*), and chain plates (*cadenas de hierro*) for the masts, although he had sufficient supplies of pulleys (*poleaje*) and deadeyes (*botonadura*). The master shipwright Pedro de Busturria was supposed to mast the galleons, but he had to leave for the port of El Ferrol in Galicia to work in the outfitting of the Armada (Figure 10). Riva Herrera doubted that the galleons would be ready to sail next summer if the masts did not arrive soon, and it was necessary also to start the search for sailors, soldiers, and ordnance for their outfitting.[110] *San*

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[108] AGS GYM Leg. 254 doc. 22.
[109] AGS GYM Leg. 280 doc. 206.
[110] AGS GYM Leg. 317 doc. 185.

Pablo, one of the largest galleons together with *San Pedro*, was ready to launch, although the lack of cables was delaying the operation. Riva Herrera finally decided to obtain some cables from the hulks that were in the port to launch the galleon during the next spring tide.[111] He also signed a contract (*asiento*) to receive canvas from Pondavid, although he had to provide an advance of the total price from his own money. Each piece of canvas measured 42 Castilian yards (*varas*), and cost 80 *reales* apiece. The canvas was to be delivered in two different shipments due to the rebellion that was taking place in France. The first shipment would arrive in February, and the second at the beginning of April.[112]

Figure 10. El Ferrol (Galicia), and the shipyards in Cuatro Villas (Cantabria) and Biscay (modified from Google Earth Pro satellite maps).

[111] AGS GYM Leg. 280 doc. 160.
[112] AGS GYM Leg. 280 doc. 160.

San Pablo was launched on Sunday, February 4, and according to eyewitnesses was the strongest and largest galleon built in Guarnizo (Table 5). Its hull was well-proportioned, the gunports were appropriately distributed along the length of the hull, and its draft was even shallower than that of the smaller galleons that Barros built in Guarnizo.[113] Moreover, it was estimated that *San Pablo* drew only half of the water required for the other two new galleons *San Pedro* and *San Andrés*. Its launching was surprisingly easy taking into account its large tonnage, over 1,000 tons (*toneladas*), because no oxen were need to pull the galleon into the water. Six longboats (*chalupas*) towed *San Pablo* half a league (*legua*) (3.17 km)[114] away from Guarnizo, where it was moored next to the other two galleons.[115] Four guns were fitted on each galleon to protect them in case of attack.[116] The fourth galleon was almost completed, and Riva Herrera intended to launch it on March 5, with the next spring tide, although more money was needed to continue the work in the shipyard.[117] A few days later, Riva Herrera received 2,000 ducats, which he used to pay four months of salary in arrears owed to the workers of the shipyard. Riva Herrera also gave 12 ducats to each of the 48 caulkers who were about to leave for the port of El Ferrol, while the rest of the money was distributed between the carpenters and other workers. At that moment, there were more than 2,000 carpenters and 80 caulkers working in Guarnizo, although many would

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[113] AGS GYM Leg. 281 doc. 75.
[114] The nautical league used by the Spanish in the 16th century was the league of 17.5 per latitudinal degree that was equal to 7,558.57 Spanish *varas* (6,349.2 m), see Serrano Mangas 2012, 109–11.
[115] AGS GYM Leg. 281 doc. 46.
[116] AGS GYM Leg. 281 doc. 75.
[117] AGS GYM Leg. 281 doc. 51; AGS GYM Leg. 281 doc. 83.

have to be dismissed without money to pay their salaries. Riva Herrera was also running out of wood because he could not afford to pay the transport costs to the shipyard, or even to buy nails.[118]

In Deusto there were only 110 carpenters working on the construction of the galleons, but Ojeda was forced to send 40 carpenters and caulkers to El Ferrol to work on the outfitting of the Armada. The launching of *San Felipe*, the fifth galleon, was set for February 19, depending on the next spring tide, while *San Bernabé* still had to be caulked.[119] *San Felipe* was finally launched on February 20, and moored with the other galleons at the anchorage of Zorroza (Table 5). Ojeda was concerned about the spreading rumors that a squadron of 20 or 30 ships ready to depart from England to burn the new galleons. For this reason, he asked for soldiers from Santander in order to protect his galleons in Zorroza. He even suggested that the soldiers could live on board the galleons while protecting them.[120] All six galleons were to be taken downstream from Zorroza to Portugalete, at the mouth of the inlet of Bilbao, after their construction was completed, and eventually would be moored past the Portugalete sandbar.[121] Alvaro de Bazán, however, recommended keeping the galleons in Zorroza where they were better protected due the difficulty of crossing the Portugalete sandbar, which required high tides. In addition, if the galleons were taken to Portugalete, the enemy could fire at them from the other side of the sandbar. In Bazán's opinion, the galleons were safer

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[118] AGS GYM Leg. 281 doc. 52; AGS GYM Leg. 281 doc. 83.
[119] AGS GYM Leg. 281 doc. 108.
[120] AGS GYM Leg. 281 doc. 111.
[121] AGS GYM Leg. 281 doc. 109.

while moored at Zorroza, 2.5 leagues (*leguas*) (15.87 km) upstream from the entrance of the inlet, protected by multiple sandbanks. In fact, all these sandbanks required that the galleons be taken downstream to Portugalete without masts and with minimum ballast to avoid the risk of running aground.[122]

The workers at the shipyard of Deusto were angry for not receiving their wages regularly, and Ojeda believed that they would leave the shipyard in 10 or 12 days if they were not paid soon.[123] In addition, it would be impossible to have the galleons ready to sail the next summer if the spars for the masts and yards of the galleons did not arrive soon. Ojeda asked the King to have them brought as soon as possible, while he began making the sails for the galleons.[124] Yet again, Ojeda pleaded for the King to assign him a salary because he had spent the last 14 months working without being paid.[125]

In March, the King ordered 50 soldiers and 25,000 ducats be sent to Deusto to protect the galleons and to continue their construction.[126] Ojeda was finally able to pay his debts, and to recover the 10,000 *reales* given to the caulkers sent to El Ferrol to cover their expenses during the journey. The arrival of the spars from Germany was taking longer than expected, and Ojeda proposed to bring them from Andalusia or even La Rochelle (France). The King had to decide if he wanted the galleons ready to sail this year or the next, because they could only be taken across the Portugalete sandbar during the summer months. Ojeda suggested keeping the galleons in Zorroza if they were not to

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[122] AGS GYM Leg. 281 doc. 85.
[123] AGS GYM Leg. 281 doc. 108.
[124] AGS GYM Leg. 281 doc. 109.
[125] AGS GYM Leg. 281 doc. 112.
[126] AGS GYM Leg. 293 doc. 218.

serve in summer 1590, where they would be better protected from unfavorable winds and guarded by 60 soldiers.[127] The last of the six galleons built in Deusto, *San Bernabé*, was finally launched on March 22 and moored with the others in Zorroza (Table 5).[128]

The galleon *Santiago* was launched on March 7 in Guarnizo and, as in the case of *San Pablo*, no oxen were needed to pull it into the water during the launching (Table 5). At the same time, the caulkers were working on the fifth galleon, and the hull planking of the sixth was almost completed.[129] Meanwhile, the carpentry and upper works of the galleon *San Pedro* were to be completed by the end of the month. According to Riva Herrera, *San Pedro* and *San Andrés* could be masted and outfitted rapidly if the spars arrived on time.[130] Riva Herrera did not have enough cables to launch another galleon, and expected Ojeda to send some to him. The galleons in Santander were also well protected by a large number of soldiers, despite Riva Herrera's complaints about the lack of gunpowder and lead shot, which had yet to be brought from Bilbao. He suggested that the galleons built in Deusto would be safer in the Bay of Santander than in Portugalete, although he was aware of the dangers of taking the galleons out from behind the sandbar to bring them to Santander.[131]

A hulk (*urca*) with 17 cables and 1,300 hundredweights (*quintales*) of rigging for the galleons arrived at Guarnizo at the beginning of April. However, the need for rigging was no longer urgent, as it had become clear that the galleons were not to be

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[127] AGS GYM Leg. 282 doc. 59.
[128] AGS GYM Leg. 282 doc. 58.
[129] AGS GYM Leg. 282 doc. 69.
[130] AGS GYM Leg. 282 doc. 73.
[131] AGS GYM Leg. 282 doc. 69.

commissioned that year.[132] Riva Herrera intended to launch the fifth galleon, *Santo Tomas*, during the next spring tide if the favorable weather continued, and to begin caulking the sixth one.[133] The general Bertendona was so impressed by the quality of the construction of *San Pedro* that he told the King that it was the best galleon he had seen in his lifetime.[134] Juan del Águila insisted upon sending more soldiers to Santander and repairing the forts of the Bay of Santander, to be prepared in case of an attack by an enemy fleet. He even recommended mooring the galleons far from each other to prevent the spread of fire if the enemy tried to burn them using longboats (*chalupas*).[135]

In Zorroza, the upper works of the galleons were almost completed and the majority of debts had been paid, although the timbers to mast the galleons had yet to arrive. Ojeda received a letter from the agent he had sent to San Juan de Luz (France) to search for spars for the galleons. The agent was about to leave for the port of La Rochelle where he was told there were large quantities of spars available, although his main concern was to find a way to transport them from France to Spain.[136] He found more than 1,500 spars of all sizes in La Rochelle, and a plan was devised to bring to Spain those needed for the new galleons. They would wait for the return of the fishing fleet from Terranova in September. This fleet consisted of several *naos* of 400 and 500 tons from San Juan de Luz which, after unloading cod from Terranova, were to go to La Rochelle to load wheat and salt. At that moment, it would be possible to load between 15

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[132] AGS GYM Leg. 283 doc. 45.
[133] AGS GYM Leg. 283 doc. 46.
[134] AGS GYM Leg. 283 doc. 29.
[135] AGS GYM Leg. 283 doc. 46.
[136] AGS GYM Leg. 283 doc. 31.

and 20 spars onto some of the *naos*, pretending they were for replacing their own masts and yards. The whole operation would be carried out with the assistance of one of the members of the city council to avoid any difficulty. According to Ojeda's agent, this was the best option to get spars for the new galleons, unless the King decided to bring them from Germany, or even Andalusia, in the south of Spain.[137]

In May, Ojeda asked the King for 12,700 *reales* to pay the remaining debts and wages that he still owed for the construction of the galleons. In addition, he also reminded the King that he was not receiving any salary for his work and that many times he had paid construction expenses thanks to the financial support of his relatives and friends. Therefore, he expected to be assigned a fair salary for his services during the construction of the galleons.[138]

The galleon *Santo Tomás* was launched in Guarnizo on May 1, the day of the religious holiday of San Felipe and Santiago, and was moored with the others, while the caulking of the sixth galleon progressed (Table 5). Riva Herrera intended to launch *San Juan*, the sixth galleon, at the end of the month or in early June at the latest (Table 5).[139] As in Deusto, the lack of funds slowed down the construction because there was a constant need of cash to buy materials and to bring them to the shipyard. With respect to the spars and rigging for the galleons, the accountant (*contador*) Francisco de Arriola

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[137] AGS GYM Leg. 284 doc. 20; AGS GYM Leg. 284 doc. 22.
[138] AGS GYM Leg. 284 doc. 19.
[139] The documents examined at the Archive of Simancas do not provide the name or the exact launching date for this galleon. However, the names of the other five galleons built in Guarnizo are known, as well as the other six built in Deusto. Therefore, since these galleons were named after the Twelve Apostles, and Monson also provides a list of all 12 ships, the last galleon built in Deusto must have been *San Juan*, see Monson 1902, 3:73-4.

mentioned that the hulk (*urca*) scheduled to bring them from Germany should have arrived in Santander in April. Riva Herrera and Ojeda both had serious doubts regarding the fulfillment of the contract (*asiento*) signed to provide the rigging for the galleons. Therefore, Riva Herrera suggested that the most important pieces of rigging be manufactured in Bilbao using hemp from Calatayud, in the Spanish region of Aragon. This hemp was more expensive and difficult to work with than the hemp from Germany that they were expecting to receive, although the end product would be of a much better quality. If the hulk (*urca*) with the rigging ever arrived in Santander, they could always use the extra rigging to outfit the ships of the Armada.[140]

Acquisition of the masts and yards for the galleons

In order to complete the outfitting of the new galleons, Riva Herrera and Ojeda needed spars to make the masts and yards for the new ships. Ojeda insisted on his plan to bring them from La Rochelle, and even asked the King for his authorization for the operation, but the plan was never executed.[141] Meanwhile, a hulk (*urca*) loaded with spars arrived in Lisbon, where Esteban de Ibarra, the General Purveyor of the Armadas of Philip II (*proveedor general de las Armadas*), tried to convince the shipmaster to bring the spars to Santander to outfit the new galleons. The shipmaster of the hulk (*urca*) claimed that the spars were for the ships of the Armada in the port of El Ferrol, although

[140] AGS GYM Leg. 284 doc. 45.
[141] AGS GYM Leg. 285 doc. 73.

he had not signed any contract (*asiento*) for provisioning them.[142] At the same time, Ibarra was negotiating with the merchant Guillermo Persi, who informed him that he was expecting the arrival in Lisbon of two hulks (*urcas*) loaded with masts suitable for large ships. These hulks (*urcas*) had left Danzig (Gdansk, Poland) with spars from Norway and Prussia.[143] In any case, the priority for Ibarra was to negotiate a price with the owner of the hulk (*urca*) that had actually arrived in Lisbon, and transport those spars to Santander. However, the merchant did not want to go to Santander, because he would lose money since there was no reciprocal cargo to be taken in Santander once the spars had been unloaded. At the same time, Ibarra had checked the availability of spars in the warehouses of Lisbon for the new galleons.[144] Meanwhile in El Ferrol, Álvaro de Bazán was also trying to convince a German merchant named Otto Vilquiens (Ottubilque) to accept a contract to provide the spars for the new galleons. Bazán thought that the galleons were so large that they would need special masts according to their individual size. Vilquiens had been the shipmaster of the Vice Admiral's hulk (*Urca Almiranta*) that took part in the expedition of 1588 Armada against England.[145] He agreed to bring the spars from Danzig (Gdansk), his hometown, and to deliver them in Santander, Lisbon or any other destination by October. However, he demanded to be paid first for his services in the Armada of 1588, which amounted between 5,000 and 6,000 ducats.[146]

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[142] AGS GYM Leg. 284 doc. 150.
[143] AGS GYM Leg. 284 doc. 149.
[144] AGS GYM Leg. 285 doc. 227.
[145] AGS GYM Leg. 285 doc. 155.
[146] AGS GYM Leg. 285 doc. 168.

Luis César, the Purveyor of the Storehouses and *Armadas* of the Crown of Portugal (*Provedor dos Amazéns e das Armadas da Coroa de Portugal*), informed Ibarra that he was not able to provide any masts from the storehouses because all of them were needed to outfit the ships that were already in Lisbon. The shipmaster of the hulk (*urca*) finally agreed to go to Norway and return with another cargo of spars that would be delivered in Santander on November 1, All Saints' Day. Considering all of these options, Ibarra believed that the fastest and cheapest option to receive the masts was to have one of the hulks (*urcas*) of Guillermo Persi bring the spars to Santander or Biscay after its arrival in Lisbon.[147] However, it seemed that the hulk (*urca*) that had arrived in Lisbon, whose shipmaster refused to bring the spars to Santander, was the same hulk (*urca*) hired by Verhagen to provide masts for the new galleons according to the original *asiento* signed with Isasti.[148] According to Verhagen, the hulk (*urca*) had arrived severely damaged in Lisbon on April 15, and the cargo had been unloaded in order to caulk its hull, which was leaking heavily.[149] As this was the same hulk (*urca*) intended to bring the masts according to the initial contract signed between Isasti and the Flemish merchant Joan de Verhagen, Arriola proposed to send to Lisbon the list with the dimensions of the masts needed for the new galleons, and to select the masts for delivery to Santander and Biscay.[150]

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147 AGS GYM Leg. 285 doc. 228; AGS GYM Leg. 285 doc. 230.
148 AGS GYM Leg. 285 doc. 50; AGS GYM Leg. 285 doc. 51.
149 AGS GYM Leg. 285 doc. 51; AGS GYM Leg. 285 doc. 49.
150 AGS GYM Leg. 285 doc. 50; AGS GYM Leg. 285 doc. 48.

In the meantime, the shipmaster of the hulk (*urca*) agreed to sail to Norway to procure the masts for the new galleons, and to deliver them in Santander for a total cost of 4,500 *escudos*.[151] A few days later, another contract (*asiento*) was signed with the merchant Otto Vilquiens to provide spars for the new galleons. He committed to bring the masts himself by January of 1591 for a total cost of 10,000 ducats.[152] Ibarra also tried to send to Santander another ship that had arrived in Lisbon at the end of June with a cargo of spars. The local merchants, however, opposed its departure because they had purchased the cargo and they needed the masts for their *naus* of India.[153] Luis César gave orders to unload the spars from this hulk (*urca*) while Ibarra negotiated with its owner Jacques Ferrer the possibility of providing another cargo of spars for the new galleons. Meanwhile there was still no news about the two hulks (*urcas*) that Guillermo Persi was expecting.[154]

In August, the upper works of the galleons in Santander were almost completed, although Riva Herrera had no funds to pay the carpenters. He owed more than 1,000 ducats to the master shipwright Domingo de Uriarte and his carpenters, who built the galleon *San Andrés*.[155] In Deusto, Ojeda thought that there were no more than 20 days of work left for the carpenters. He had started making the sails, and calculated that he would need only 200 pieces of canvas for his six galleons out of the 600 purchased for

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[151] AGS GYM Leg. 286 doc. 129; According to Phillips (1992, 28) an *escudo* was a gold coin worth 12-15 *reales* at the beginning of the 17th century.
[152] AGS GYM Leg. 286 doc. 86.
[153] AGS GYM Leg. 287 doc. 175.
[154] AGS GYM Leg. 287 doc. 182; AGS GYM Leg. 287 doc. 183.
[155] AGS GYM Leg. 287 doc. 57.

the 12 galleons, along with 300 hundredweights (*quintales*) of rigging that were to be made in Bilbao.[156] Ojeda had also run out of money to pay the workers and the suppliers, although he had already been reimbursed for all the arrears to the soldiers who guarded the galleons. He asked the King for more funds, and for an inspector to review his accounts on the construction of the galleons.[157] Since the galleons were already completed, Ojeda also recommended to begin the search for ordnance to arm the newly built ships.[158] Álvaro de Bazán still advocated for bringing the galleons to Santander before contrary winds and tides prevented taking them across the sandbar of Portugalete. He proposed to outfit the galleons with provisional rigging to sail to Santander, made from the masts of the hulks (*urcas*) and pinnaces (*pinazas*) that were in Portugalete.[159] The members of the Council of War (*Consejo de Guerra*), however, concluded that it was safer for the galleons to remain in Bilbao. They assessed that the dangerous coastline, and the fact that the galleons would not be fully rigged, made the journey from Portugalete to Santander too risky.[160]

The economic situation was not much better in Santander, where there was a great need of money to pay the salaries owed to the carpenters, caulkers, and sailors. Construction had been running for six months without workers receiving any payment. The workers had survived by borrowing money in the surroundings of the shipyard, but now that construction was complete, nobody was willing to lend them additional money.

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[156] AGS GYM Leg. 287 doc. 33; AGS GYM Leg. 287 doc. 34.
[157] AGS GYM Leg. 287 doc. 33.
[158] AGS GYM Leg. 287 doc. 35.
[159] AGS GYM Leg. 287 doc. 112.
[160] AGS GYM Leg. 300 doc. 225.

Many carpenters had been dismissed a couple of months earlier, and some of them were literally dying of hunger. Even the sailors in charge of the galleons were prepared to leave the shipyard if they did not receive their wages. The only good news was that no workers died during the construction phase of the galleons.[161]

Figure 11. Location of Sanlúcar de Barrameda (Cádiz, Andalusia) with respect to Lisbon, El Ferrol, Guarnizo, and Deusto (modified from Google Earth Pro satellite maps).

[161] AGS GYM Leg. 288 doc. 36.

With the situation becoming more desperate regarding the masts needed for the galleons, the Duke of Medina Sidonia informed the King about an 800-ton hulk (*urca*) full of spars arriving at Sanlúcar de Barrameda in Cádiz (Figure 11). The ship belonged to the King of Sweden, and was carrying 200 spars of every size that Medina Sidonia thought could serve to outfit the new galleons.[162]

Meanwhile in Deusto, Ojeda suggested using the ordnance of the *nao* of Ortiz de Larrea to arm his galleons. This *nao* wrecked on November 17 on the sandbar of Portugalete as it was about to enter port, and was carrying 23 bronze and cast iron guns, whose salvage was in the charge of Baltasar de Lezama. Ojeda had finally received 24,000 ducats from the King, which paid for all the debts and wages that he owed through at least the end of October. A total of 20,000 ducats were to cover construction expenses, while the remaining 4,000 ducats were to buy supplies to outfit the galleons. The construction was completed in November, and the galleons were moored and guarded in Zorroza. The King also ordered master carpenter Pedro de Busturria to go to El Ferrol to work on outfitting the Armada, and Ojeda gave him 300 *reales* for the journey. The galleons only needed to be masted, and 111,470 *maravedises* were allocated to pay the carpenters to make the masts, and the crew of the pinnaces (*pinazas*) that were to take the galleons downstream to Portugalete.[163]

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[162] AGS GYM Leg. 289 doc. 170; Phillips (1992, 228) indicates that a *maravedí* was the smallest unit of money of account. 34 *maravedís* made 1 real, 375 *maravedís* were equal to 1 ducat, 340 *maravedís* to 1 *escudo*, and 272 *maravedís* to 1 *peso*.
[163] AGS GYM Leg. 290 doc. 157; AGS GYM Leg. 290 doc. 158.

The Council of War expected the new galleons to be ready to join the Armada in the spring of 1591. According to their tonnages, the 12 galleons would need about 2,000 sailors and 400 pieces of artillery. Unfortunately, the foundries of Lisbon and Malaga were unable to make so many pieces due to the lack of foundrymen and materials; therefore, part of the ordnance had to be purchased abroad. Since there was no news about the hulks (*urcas*) that Ibarra was expecting in Lisbon, Medina Sidonia was finally ordered to send the spars he had in Andalusia.[164] At the end of December, however, Ibarra informed the King about the arrival in Lisbon of two more hulks (*urcas*) from Lübeck (Germany), which had been sailing together with the hulk (*urca*) that was bringing the masts for the new galleons according to the new contract made with the merchant Jacques Ferrer. However, these hulks (*urcas*) became separated off Cape Finisterre due to a storm on November 20, and there was no news about the hulk (*urca*) with the masts even though it was expected to arrive in Lisbon shortly. Moreover, there was no news either about the hulk (*urca*) that had to deliver the spars directly to Santander according to the first contract (*asiento*) signed by Ibarra with the shipmaster of the first hulk (*urca*) that had arrived in Lisbon.[165]

Regardless, Medina Sidonia had already received the order to select the spars for the new galleons and to send them to Santander. He reckoned that 300 spars should suffice to make the masts and yards of the 12 new galleons. The initial plan was to load all the spars in two hulks (*urcas*) to transport them to Santander and, if there were any

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[164] AGS GYM Leg. 301 doc. 156; AGS GYM Leg. 291 doc. 19.
[165] AGS GYM Leg. 291 doc. 22.

surplus spars, they could be taken to El Ferrol for use in outfitting the Armada.[166] Unfortunately, only 140 spars of the appropriate dimensions for the new galleons could be fitted into the hulks (*urcas*). Medina Sidonia therefore suggested that the remaining spars needed for the galleons could be brought from Lisbon utilizing the hulks (*urcas*) from Lübeck and Danzig (Gdánsk, Poland), which had already arrived in Lisbon. He intended to pay 1,850 ducats to each hulk (*urca*) for transporting the spars: 850 ducats in Sanlúcar, and the remaining 1,000 ducats upon the delivery of the cargo.[167] However, another hulk (*urca*), almost as large as the ones Medina Sidonia had commandeered to carry the spars to Santander, arrived from Lübeck in Cadiz at the beginning of January 1591. The Duke suggested to the King that the rest of the spars be loaded onto this hulk (*urca*) since one of the others was already laden with 99 pieces. Medina Sidonia also wanted to embark Spanish soldiers in the hulks (*urcas*) to ensure that their owners actually delivered the masts to Santander. The King, on the other hand, thought that it would be sufficient if the owners provided deposits (*fianzas*) before their departure.[168]

Again in January, Ibarra sent to the King a list of the masts from Norway and Prussia that were already in Lisbon, since he thought that any of them would serve the ships of the Armada well, including the new galleons of Santander and Deusto.[169] There was still no news about the hulk (*urca*) of the first contract (*asiento*), which should already have arrived in Santander, unless it had sunk or had been captured during the

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[166] AGS GYM Leg. 291 doc. 194.
[167] AGS GYM Leg. 291 doc. 195.
[168] AGS GYM Leg. 317 doc. 42.
[169] AGS GYM Leg. 317 doc. 19; AGS GYM Leg. 341 doc. 32.

journey to Spain. Moreover, Ibarra was also waiting for the hulk (*urca*) of Jacques Ferrer bringing the other cargo of spars for the new galleons to Lisbon.[170] Jacques Ferrer's hulk (*urca*) finally arrived in Cascais a few days later, badly damaged from a storm. It had to be repaired before departing to Santander, and those repairs would further delay the delivery of the masts. In addition, the loss of the hulk (*urca*) of the first contract (*asiento*) was confirmed, since two ships that had departed two weeks after that hulk's (*urca*) departure had just arrived in Lisbon.[171] In Sanlúcar, Medina Sidonia ultimately decided to embark Spanish soldiers in the hulks (*urcas*) to ensure the delivery of the spars. Given all of the changes, the total cost of the masts became 42,124 *reales* in addition to 850 ducats that he had promised to the ships' masters. Medina Sidonia expected two of the vessels to depart soon, while the third hulk (*urca*) was to leave Sanlúcar shortly afterwards.[172]

Ojeda also informed the King about the need to careen the galleons in Deusto before their departure. The hulls seemed watertight since there was no need to use pumps. However, the galleons, especially the first ones to be launched, had been in the water for more than a year, and careening would prevent any threat from shipworms (*broma*). Moreover, it would be less expensive to careen the galleons in Zorroza than in any ultimate port of destination. According to Ojeda, the careening could start in mid or late February, and would be completed by the time that the masts arrived. However,

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[170] AGS GYM Leg. 317 doc. 19.
[171] AGS GYM Leg. 317 doc. 20.
[172] AGS GYM Leg. 317 doc. 43.

Ojeda needed money for the careening, and despite his multiple petitions, he still had not been assigned a salary.[173]

The King expected the galleons, or at least some of them, to be outfitted and ready to sail by the summer of 1591, and requested a full report from Ojeda regarding their condition.[174] According to Ojeda's report, the construction of the galleons, including carpentry, caulking, and painting of the sterns, had been completed. His six galleons could be masted and ready to sail by the end of May if the spars arrived in February.[175] In such a case, only the galleons that were to stay at port would need to be fully careened. However, Ojeda had no artillery, gunpowder, or shot to arm his galleons, except for the 18 bronze and cast iron pieces salvaged from the *nao* of Ortiz de Larrea that had sunk on the sandbar at the entrance of Portugalete on November 17.[176] The galleons also needed provisions such as bacon, salted meat, Rioja wine, biscuit, cheese, and dry legumes (*menestra*), which could be provided from Biscay. Finally, Ojeda required 100 hundredweights (*quintales*) of cordage and cables in addition to the 1,059 hundredweights (*quintales*) of rigging ordered the previous year, to replace the rigging worn from use.[177]

In Guarnizo, Riva Herrera was ordered to send master shipwright Pedro de Busturria and 80 Biscayan carpenters and caulkers to El Ferrol to work on the outfitting of the Armada. Ultimately Busturria departed with only 12 carpenters because Riva

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[173] AGS GYM Leg. 317 doc. 182.
[174] AGS GYM Leg. 329 doc. 125.
[175] AGS GYM Leg. 317 doc. 183; AGS GYM Leg. 317 doc. 183.
[176] Supra n. 163.
[177] AGS GYM Leg. 317 doc. 183.

Herrera needed the others to prepare his galleons for the summer. Riva Herrera even accused Ojeda of keeping 34 of the best carpenters and caulkers to work in Deusto. In any case, Riva Herrera expected that more carpenters would join Busturria on his way to the port of El Ferrol.[178] The galleons of Guarnizo also needed to be careened before joining the Armada, and Riva Herrera needed funds to pay for the work, as well as for sails, tackle, and cordage. Moreover, he had also built pinnaces (*pinazas*), *zabras*, small boats (*bateles*), skiffs (*esquifes*), and longboats (*chalupas*) to service the galleons, and had to pay for all of them as well.[179] Riva Herrera was waiting for the hulks (*urcas*) with the spars from Sanlúcar, and he promised the King that the shipmasters would bring half of the spars to Bilbao after unloading the first half in Santander. However, based on a report that Riva Herrera received regarding the dimensions of the spars, he considered that they were too thin. Their maximum girth was only 10 palms (*palmos*) (2.09 m), when he considered they should be at least 13 or 14 palms (2.71 – 2.93 m); additionally, their lengths were not included in the report. In his opinion, it would be necessary to girdle (*embonar/gemelgar*) the spars to obtain the appropriate thickness. Riva Herrera also suggested bringing two carpenters from Lisbon, one for Santander and the other for Bilbao, to help with the masting of the galleons, because carpenters in Portugal were used to masting such large vessels. Like Ojeda, Riva Herrera also needed sails and rigging for the galleons.[180]

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[178] AGS GYM Leg. 317 doc. 181; AGS GYM Leg. 317 doc. 186.
[179] AGS GYM Leg. 317 doc. 181.
[180] AGS GYM Leg. 318 doc. 88.

In February, Ojeda asked Lezama for the artillery salvaged from the *nao* sunk in Portugalete to arm the galleons in Deusto. Lezama, however, was reluctant to turn them over to him without an order from the King, although he finally agreed when Ojeda promised to return them as soon as the King ordered it. The careening (*dar de lado*) of the galleons had already begun, and Ojeda expected to complete it as soon as possible if the favorable weather lasted. The first galleon to be inspected was *San Matías*, whose lower hull was exposed down to the fourth strake above the keel, without discovering any trace of shipworms (*broma*). The condition of the hull was so good that there was no need to add any oakum between the planking seams and, therefore, its hull was only breamed. Ojeda expected the other galleons to be in a similar condition because they had been in water for even a shorter time.[181] The King directed Ojeda to finish the work as soon as possible, as both men expected that hulks (*urcas*) with masts would arrive soon.[182] The galleons were to be brought downstream from Zorroza to Portugalete to be masted, and the best window to move the galleons was between mid-March and end of April, to avoid encountering contrary winds. Moreover, if the galleons were to winter in Portugalete, they needed more powerful ordnance than the artillery salvaged from the *nao* sunk on the sandbar.[183]

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[181] AGS GYM Leg. 318 doc. 170.
[182] AGS GYM Leg. 330 doc. 151.
[183] AGS GYM Leg. 318 doc. 169.

The hulks (*urcas)* with the spars depart from Sanlúcar

The three hulks (*urcas*) were finally laden with 254 masts for the new galleons and, since the shipmasters refused to provide any deposit, Medina Sidonia ordered soldiers to embark the ships to ensure the delivery of the spars. A Biscayan pilot and two experienced sailors were assigned to each hulk (*urca*). Just before the hulks (*urcas*) were to set sail, Medina Sidonia received a letter from King directing that one of the ships be left in Sanlúcar, because one of Persi's hulks (*urcas*) that Ibarra was expecting in Lisbon had finally arrived, and the other was probably in Santander. Medina Sidonia had to select the best and largest spars, and send them to Santander in only two *urcas*, but he considered that it would be a great inconvenience to delay the departure of the hulks (*urcas*) to unload and select the best quality spars. Therefore, he ordered the departure of all three *urcas,* which set sail from Sanlúcar on February 19, 1591. He suggested that the galleons built in Deusto should be fitted with provisional rigging (*bandolas*) and taken to Santander under the escort of armed pinnaces (*pinazas*), to ensure there were enough masts for all of them, and to avoid the likelihood that Riva Herrera kept the best masts in Santander.[184] Riva Herrera also preferred to bring all the galleons to Santander due to the dangerous Portugalete sandbar. In his opinion, it would be easier to take the galleons out of Portugalete before they were fully masted, and outfit them afterwards.[185]

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[184] AGS GYM Leg. 318 doc. 126.
[185] AGS GYM Leg. 318 doc. 91.

The arrival of the hulks (*urcas)*

The hulks (*urcas*) arrived in Santander a week later, but were unable to enter the bay for three days due to adverse south wind. Therefore, the hulks (*urcas*) headed for the ports of Laredo and Santoña, where Riva Herrera had sent some men to prepare for just this eventuality (Figure 12).[186] In the end, the only hulk (*urca*) that entered the port of Santoña was *Tobías,* which arrived badly damaged, laden with 68 large spars and 80 soldiers.[187] The other two hulks (*urcas*) arrived in Santander a day later with the rest of the masts and 220 soldiers on board.[188]

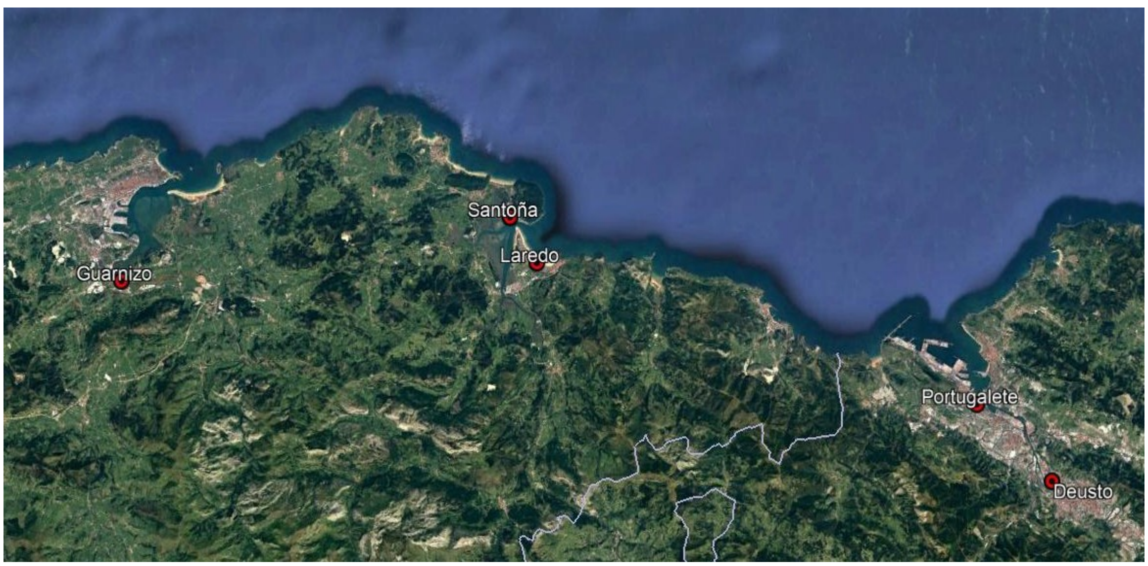

Figure 12. Location of the ports of Santoña and Laredo in Cuatro Villas (Cantabria) (modified from Google Earth Pro satellite maps).

[186] AGS GYM Leg. 318 doc. 91.
[187] AGS GYM Leg. 318 doc. 99.
[188] AGS GYM Leg. 318 doc. 107; AGS GYM Leg. 318 doc. 109.

The distribution of the spars between Santander and Deusto

As the damaged hulk (*urca*) arrived in Santoña, Ojeda was careening *San Simón,* which had been damaged by an accidental fire during careening that, fortunately, only affected the stern of the galleon, and whose repair would not cost more than 80 escudos. Ojeda immediately sent sailors and pilots to Santoña to bring the hulk (*urca*) to Portugalete. He even suggested to the King that the soldiers who came with the hulk (*urca*) could serve onboard the new galleons.[189] However, the mayor (*corregidor*) of Cuatro Villas (Cantabria) began creating excuses to prevent the departure of the hulk (*urca*) from Santoña. According to him, the draft of the hulk (*urca*) was too deep for the Portugalete sandbar, although Ojeda argued that its draft of 8.5 or nine cubits (4.89 or 5.17 m), could easily be accommodated by the depth at the entrance of Portugalete, which was between 11 and 12 cubits (6.32 and 6.9 m) at high tide. The mayor (*corregidor*) insisted that the hulk (*urca*) go to Santander instead and, if that was not possible, to unload the spars in Laredo. He suggested that Ojeda could make rafts (*balsas*) with the spars, and tow them to Portugalete using pinnaces (*pinazas*). Ojeda disagreed with that option because it was impractical due to bad weather and the difficulties of navigation. In any case, Ojeda ordered 78 spars be unloaded for his galleons.[190]

The other two hulks (*urcas*) that arrived in Santander were *Sansón* and *Leon Dorado*. Riva Herrera wrote to the hulk (*urca*) captain Vasco Rodríguez in Laredo and

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[189] AGS GYM Leg. 318 doc. 172.
[190] AGS GYM Leg. 318 doc. 171.

asked him to bring the hulk (*urca*) *Tobías* to Portugalete, if its draft allowed it to cross the sandbar. However, Rodríguez replied that the draft of the hulk (*urca*) was too deep to enter the port safely, and that even the shipmaster refused to sail to Portugalete. Therefore, the pilots that Ojeda had sent to Laredo returned to Bilbao. The shipmaster of the hulk (*urca*) *León Dorado* and the pilots of Santander also agreed that it was not appropriate to bring the hulks (*urcas*) to Portugalete because they could wreck on the sandbar. The shipmasters even refused to tow the masts to Portugalete. Moreover, the sizes of the spars loaded on the hulks (*urcas*) were not evenly distributed. For instance, the hulk (*urca*) that arrived in Laredo carried most of the thickest masts with girths between 10 and 11 palms (2.09 and 2.30 m), and only one mast thinner than seven palms (1.46 m). The hulk (*urca*) *Sansón*, on the other hand, carried mostly thin masts, with only one piece having a girth of 11 palms (2.30 m), while the majority had girths of four (0.84 m), five (1.05 m), and seven palms (1.46 m). For this reason, Riva Herrera proposed to distribute between himself and Ojeda the masts that were in Laredo, to ensure that they both received the thickest spars for the mainmasts of the new galleons. In addition, Riva Herrera would also give Ojeda half of the masts that were in Santander, and even pieces of oak to be used as masts heels (*coces de roble*) in case Ojeda needed them.[191]

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[191] AGS GYM Leg. 319 doc. 133.

Outfitting the galleons for the Armada

At the end of February, the King ordered six of the new galleons to serve in his Armada during the summer of 1591. Both Riva Herrera and Ojeda had to choose three of their galleons, one of each size, and completely outfit them. Ojeda selected *San Matías* (large), *San Simón* (medium-sized), and *San Bernabé* (small) to take downstream to Portugalete with the first spring tides (between March 24 and 25). All the outfitting that depended on Ojeda was already completed, while Baltasar de Lezama still had to provide the cables and rigging for the galleons. The masts had not yet arrived, but Ojeda expected to have the ships ready within two and a half months. Additionally, the galleons needed both ordnance and competent shipmasters. Ojeda also recommended the purchase of pinnaces (*pinazas*) in Santander to service the galleons.[192] Riva Herrera chose the galleons *San Pablo* (large), *San Andrés* (medium-sized), and *Santo Tomás* (small) to be completely outfitted. These galleons also had to be masted, and required artillery and provisions for the crew.[193]

By the end of March, however, Ojeda had not yet received the masts. He estimated that the galleons could be masted in 25 days after the arrival of the spars. Ojeda was still convinced that Captain Vasco Rodríguez could have sailed his hulk (*urca*) with the masts directly to Portugalete with the assistance of the pilots and sailors that he had sent to Santoña. An even better option would have been to take the smaller

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192 In fact, the large galleon chosen by Agustín de Ojeda was the *San Felipe* instead of the *San Matías*, see AGS GYM 319 doc. 113.
193 AGS GYM Leg. 319 doc. 137.

hulk (*urca*) *León Dorado* from Santander to Portugalete, since it drew only seven cubits of water (4.02 m) and thus could have safely crossed the sandbar even at low tide. However, Riva Herrera decided unilaterally to unload the masts in Santander and Laredo. He based his decision on the refusal of the masters of the hulk (*urca*) to bring them to Portugalete. According to them, their contract (*asiento*) did not include the obligation to deliver the spars to any port beyond Santander. Therefore, Riva Herrera told Ojeda to send a master carpenter to Laredo to choose the masts for Ojeda's galleons since the best masts were there, and the same hulk (*urca*) would then deliver the selected masts to Portugalete. Riva Herrera assured the King that the German merchants would pay for the transport of the masts and, if that was not possible, he himself would cover the expenses. Of course, Riva Herrera ultimately would have sent the bill to the King.[194]

Ojeda was planning to start bringing the galleons downstream from Zorroza to Portugalete at the end of March.[195] Transporting the galleons to Portugalete was not as easy as Ojeda expected due to bad weather, including river flooding caused by the melting snow in the mountains. Ultimately, Ojeda decided to wait for the next high tide to try again. In any case, this transport delay would not postpone the outfitting of the galleons, since the masts had yet to arrive in Portugalete.

It should be noted that not even General Martín de Bertendona believed the excuses advanced by Riva Herrera about the deep draft of the hulk (*urca*) and the

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[194] AGS GYM Leg. 319 doc. 142.
[195] AGS GYM Leg. 319 doc. 114.

Portugalete sandbar preventing the delivery of the spars to Portugalete.[196] The representative that Ojeda sent to Santander and Laredo to select the masts returned to Bilbao in April, and informed him that Riva Herrera had set aside only 40 masts in Santander for Ojeda's galleons. Riva Herrera justified his decision by saying that the spars in Laredo were of better quality, and it would be more convenient to bring those to Portugalete because they were closer. However, he also ordered the masts of that hulk (*urca*) to be unloaded, and brought to Santander with the three largest ones for his own galleons. To summarize, Riva Herrera chose the spars he desired from all of the hulks (*urcas*), and left only 109 spars for the galleons in Portugalete.[197]

On April 8, Ojeda started moving the galleons to Portugalete, but contrary winds prevented the completion of the move, and only *San Bernabé* was taken to Portugalete where it was safely moored. *San Simón* remained in San Nicolás, half way down the river, and Ojeda expected to bring *San Simón* and *San Felipe* to Portugalete with the next spring tide on April 23. At last, the first 36 spars had arrived in Portugalete, towed as four rafts (*balsas*) the day before, and the carpenters immediately began making the masts for the galleons. Ojeda expected the masting of *San Bernabé* to be completed within 15 days.[198] Meanwhile in Santander, Riva Herrera prepared the derricks (*cabrias*) to mast two of his galleons. The masts for the first galleon were already prepared, and the ones for the second ship were being shaped. He also asked the King for funds to buy

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[196] AGS GYM Leg. 319 doc. 128.
[197] AGS GYM Leg. 320 doc. 104.
[198] AGS GYM Leg. 320 doc. 105.

provisions for the galleons, and provided a list of the shipmasters proposed for the galleons.[199]

The mainmast of *San Bernabé* was set in place on April 18, and Ojeda intended to fit the foremast and bowsprit the following day. The masts of *San Simón* were being shaped at the same time and, if the rest of the spars arrived soon, the three galleons could be completed very rapidly. Ojeda expected to finish moving *San Simón* and *San Felipe* to Portugalete during the following four days assisted by the next spring tide, if the good weather lasted.[200] Bertendona thought that *San Bernabé* could to be fully masted in just eight days and, in fact, all three galleons would be ready even before their sailors were enlisted. However, the delay in the arrival of the remainder of the masts was also postponing the completion of the other galleons. Bertendona considered the draft of *San Bartolomé* sufficiently shallow to cross the Portugalete sandbar since it only drew eight cubits (4.6 m) of water.[201] *San Felipe* finally arrived in Portugalete on April 23, at the same time as the rest of the spars, while *San Simón* was expected to arrive from San Nicolás the following day. The priority for Ojeda now was to enroll the crew for the galleons, since the strength of the Armada would rest heavily upon the new galleons.[202] Ojeda wanted to have all three galleons ready by the end of May.[203] The remaining 73 spars of the 109 pieces selected by Riva Herrera for Ojeda arrived on four rafts (*balsas*) from Laredo, and four more from Santander. The mainmast, foremast, and bowsprit of

[199] AGS GYM Leg. 320 doc. 69.
[200] AGS GYM Leg. 320 doc. 107.
[201] AGS GYM Leg. 320 doc. 122.
[202] AGS GYM Leg. 320 doc. 108; AGS GYM Leg. 320 doc. 123.
[203] AGS GYM Leg. 320 doc. 106.

San Bernabé had already been fitted in early May, and *San Simón* stepped its mainmast and foremast. The mainmasts and foremast for *San Felipe* were being carved and shaped, although it was taking longer than the others because they were made of many pieces, while the topmasts (*gavías*) and yards (*vergas*) would be ready sooner because they were easier to make. Ojeda also informed the King that the heels of the mainmasts were made of oak and pine that he had prepared in advance.[204]

In early May, the King sent Captain Vasco Rodríguez to Santander to be in charge of the distribution of the spars brought by the three hulks (*urcas*), to ensure there were enough pieces for all the galleons, and that no spars were wasted during the making of the masts. Riva Herrera claimed that he had made a careful selection and distribution of the spars, although Ojeda had the advantage that the hulk (*urca*) with the best quality spars arrived in Laredo, only seven leagues (44.45 km) from Portugalete. Therefore, Ojeda decided to equally distribute the spars of that hulk (*urca*) between himself and Riva Herrera. Riva Herrera then began to make the masts in the manner desired by Captain Rodríguez; the mainmasts and foremasts of the galleons *San Andrés* and *Santo Tomás* had already been fitted, including some of the yards and parts of the rigging, and the mainmast of *San Pablo* was fitted on Sunday, May 12. He expected to have the three galleons masted and fully rigged within ten days, although none of the sailors enrolled for the galleons had arrived yet, and, without them, the galleons could not leave Santander. The galleons also needed shipmasters. Riva Herrera was also to organize in

[204] AGS GYM Leg. 321 doc. 173.

the next four to six days the provision of water (*aguada*) for the galleons because it required time to be completed. Moreover, Lezama and Arriola still had to send the rest of the rigging, while Riva Herrera kept stockpiling provisions for the departure of the galleons.[205] He estimated that the three galleons would need about 1,000 men to join the Armada in El Ferrol.[206]

Ojeda was also waiting for the remainder of the 1,159 hundredweights (*quintales*) of rigging that he required to outfit the galleons. Arriola had already sent him 559 hundredweights (*quintales*) but Ojeda was still waiting for the remaining 600 hundredweights (*quintales*) that Lezama had to provide.[207] According to Lezama, all the rigging requested by Ojeda had already been delivered, except for 13 hawsers (*cablotes*) of four hundredweights (*quintales*) each, and some small cordage that was still being twisted from hemp threads (*colchar*), although bad weather was delaying the work because it had to be done outdoors. Even so, Lezama expected to deliver everything within the next few days. Lezama, however, complained because Ojeda was constantly ordering more rigging than he had initially requested, although the real problem was a shortage of hemp to make the rigging. Moreover, Lezama asked the King if he was responsible for providing the supplies and provisions for the new galleons.[208] Ojeda, on the other hand, informed the Council of War that the delay in the outfitting of the galleons was Lezama's fault for not providing all the rigging materials, which included

[205] AGS GYM Leg. 321 doc. 125/126; AGS GYM Leg. 321 doc. 126; AGS GYM Leg. 321 doc. 150; AGS GYM Leg. 321 doc. 145.
[206] AGS GYM Leg. 321 doc. 123.
[207] AGS GYM Leg. 321 doc. 174.
[208] AGS GYM Leg. 321 doc. 179.

hawsers (*cablotes*), main shrouds (*obenques mayores*), and shrouds for the foremasts (*trinquetes*). By May 13, Ojeda had two of the galleons masted, but they could not be rigged due to a lack of sufficient rigging.[209]

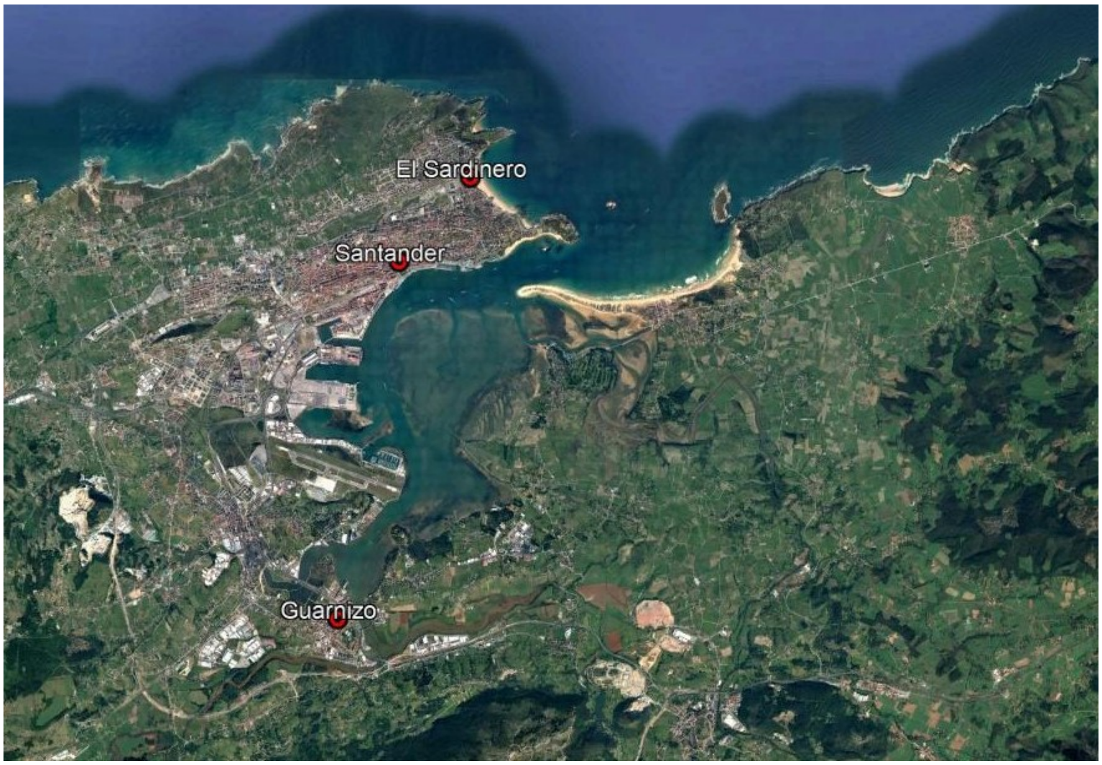

Figure 13. El Sardinero, Santander, and Guarnizo in Cuatro Villas (Cantabria) (modified from Google Earth Pro satellite maps).

Meanwhile in Santander, Riva Herrera continued masting and rigging the galleons as fast as he could in order to have them ready for the arrival of General Antonio de Urquiola, who was to take them to El Ferrol to join the Armada of Álvaro de

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[209] AGS GYM Leg. 321 doc. 174.

Bazán. Riva Herrera, however, did not know the anticipated date of Urquiola's arrival from Pasajes. He suggested that Urquiola send a longboat (*chalupa*) or *zabra* upon his arrival to let him know, and then Riva Herrera would meet him at the anchorage (*surgidero*) of El Sardinero with the new galleons (Figure 13). The sailors for the galleons had finally arrived, and Riva Herrera was also distributing the victuals among the vessels. The captains for the three galleons were to be Hernando de Vallejo, Tomas de Landagorreta, and Vasco Rodriguez. After the departure of the three galleons, Riva Herrera would continue making the masts for the other three galleons, and would store them in a dry location until they were fitted on the vessels.[210]

On May 16, the King ordered Riva Herrera to load some of those spars in the three galleons that were going to El Ferrol, and Ibarra was ordered to send one hulk (*urca*) laden with spars from Lisbon to Santander. However, Riva Herrera had already began shaping the masts for the galleon *San Pedro*, and the number of spars available in Santander was very limited.[211] The orders for Urquiola were to stop in Santander on his way to El Ferrol to pick up the three galleons built by Riva Herrera, although it would be impossible if there was any bad weather since the anchorage of El Sardinero was exposed to almost any unfavorable wind.[212] In any case, everything seemed ready for the departure of the galleons *San Pablo*, *Santo Tomás* and *San Andrés*. The victuals for the journey to El Ferrol, including wine, biscuit, fish, oil, vinegar, bacon, cheese, and

[210] AGS GYM Leg. 321 doc. 128.
[211] AGS GYM Leg. 321 doc. 130.
[212] AGS GYM Leg. 321 doc. 194.

legumes (*menestra*) were already on board, although the crews were still incomplete.[213] At this time, Álvaro de Bazán decided to send master carpenter Antonio Franco, who had masted the Portuguese galleon *San Martín*, and captain Pantaleón González to Santander to check the quality of masts of the new galleons. According to rumors in El Ferrol, the masts had iron bolts (*cabillas de hierro*) that crossed their whole section which could cause the masts to crack. Nevertheless, Riva Herrera reported that, after inspecting the masts, both Franco and González declared that the masts were made correctly; only a few nails were used to attach their fish (*gimelgas*), and not even the galleon *San Martín* had better masts than the newly built galleon *San Pablo*. It was determined that both Franco and González would return to El Ferrol on the new galleons.[214]

Bringing the galleons from Santander to El Ferrol

Urquiola left Pasajes on May 28 and arrived at El Sardinero the following day. He visited the new galleons and found out that their outfitting was so far behind schedule that he considered continuing his journey to El Ferrol without them. However, Riva Herrera offered to provide him with the provisions that he required, and Urquiola, in keeping with the King's orders, decided to stay and wait. According to Urquiola only 11 spars were loaded on *San Pablo* and *Santo Tomás* because there was no room for more. It was impossible to load any spars on *San Andrés* because the gunports (*portas*) through

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[213] AGS GYM Leg. 321 doc. 146; AGS GYM Leg. 321 doc. 148.
[214] AGS GYM Leg. 321 doc. 131.

which they were to be taken aboard were too small.[215] The galleon *San Andrés* was taken out of port on May 30, and *San Pablo* and *Santo Tomás* sailed Saturday, June 1, although their rigging was slack because it was new.[216] Urquiola considered that the masts and topmasts of the galleons were too thin and weak, and he brought all the people he could to fix them overnight for the journey to El Ferrol. The galleons were also undermanned, and Urquiola distributed 260 sailors, cabin boys (*grumetes*) and pages (*pajes*) from his own ships between the three new galleons. He embarked 120 sailors in *San Pablo*, and the rest were distributed among the other two galleons, including two pilots for each galleon. In addition, three barrels of gunpowder were transferred to each of the new galleons despite their shortage of guns.[217] The galleons also carried 3,131 hundredweights (*quintales*) of biscuit, 396 barrels (*botas*) of water, and other provisions for the journey to El Ferrol. At the end, Bazán did not send the captains he had promised for the galleons, and *San Pablo* was assigned to Captain Tomás de Landagurreta, *San Andrés* to Pantaleón González, while Urquiola appointed Juan de Lizarde as captain for *Santo Tomás*.[218] Vasco Rodríguez had a positive opinion about the quality of the new galleons, which he considered very light vessels due to their shallow drafts. According to him, the deepest draft was only 10 cubits (5.75 m), which was sufficiently shallow to sail over the Sanlúcar sandbar even at low tide.[219]

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[215] AGS GYM Leg. 322 doc. 105.
[216] AGS GYM Leg. 322 doc. 77.
[217] AGS GYM Leg. 322 doc. 105.
[218] AGS GYM Leg. 322 doc. 77.
[219] AGS GYM Leg. 322 doc. 98.

Urquiola arrived at El Ferrol on June 16, and the galleons were towed into the port with galleys due to the contrary winds. The new galleons arrived with badly damaged masts. In Bazán's opinion, this occurred because the carpenters of Cantabria (Cuatro Villas) and Biscay did not know how to build such large ships and, therefore, did not know how to mast them properly, especially because large ships required masts made of several pieces. Had he recognized this potential problem, he would have sent skillful Portuguese master carpenters to Santander for the task of masting the new galleons, even if that meant delaying their arrival in El Ferrol. In any case, it should be noted that the other ships in Urquiola's squadron also arrived with their masts damaged. One should also consider that the new galleons were not fully rigged, although Riva Herrera had promised to supply all the needed rigging. Bazán also had to borrow guns from six vessels of the Armada in order to arm the new galleons.[220]

Meanwhile in Portugalete…

Ojeda was completing the outfitting of the three galleons stated to join the Armada in El Ferrol. The provisions for the galleons were loaded on smaller ships that would follow the galleons across the sandbar; the victuals were then to be transferred to the large ships on the open sea. The galleons only needed a few more cables that were delayed in production because of the bad weather. Lezama delivered all the remaining rigging, except for three joined cables (*ayustes*) of 120 fathoms that could not be

[220] AGS GYM Leg. 322 doc. 34.

completed due to the bad weather.[221] The weather and the concerns of the pilots delayed the departure of the galleons. According to Bertendona, the pilots were worried that the galleons could run aground on the Portugalete sandbar due to their deep draft. However, Bertendona successfully took out his own vessels on June 9, which did not draw any less water than the galleons. Therefore, he expected to be able to pull out the galleons in 10 or 11 days.[222]

Ojeda also blamed the pilots, because the galleons had been ready to depart for some time. The recent flooding and storms had accumulated more sand on the sandbar, reducing its depth, and the tides were not as high as usual. Therefore, it was agreed to lighten the galleons in order reduce their draft by about 0.33 cubit (0.19 m) to take them over the sandbar. The drafts of the galleons at that moment, with all the rigging on board, were 7.75 cubits (4.46 m) for the small and medium-sized, and 8 cubits (4.6 m) for the largest, *San Felipe*. The objective was to reduce the drafts to about 7.5 cubits (4.31 m) for all three galleons. Even after lightening ship, however, they still had to wait a few days for an adequate number of sailors to arrive before being able to sail the galleons out of port. Per Bertendona's suggestion, they would wait 11 days until the next high spring tide (*aguas vivas*).[223]

The galleon *San Bernabé* was finally towed out of the port on June 21, while *San Felipe* and *San Simón* followed at dawn the next day during the morning high tide. The

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[221] AGS GYM Leg. 322 doc. 110.
[222] AGS GYM Leg. 322 doc. 108.
[223] AGS GYM Leg. 322 doc. 114; AGS GYM Leg. 322 doc. 116; AGS GYM Leg. 322 doc. 115; AGS GYM Leg. 322 doc. 117.

galleons were anchored outside of the sandbar to take on ballast, victuals, and artillery, although only 150 sailors showed up, and the pilots refused to embark because they had not been paid. The shortage of artillery was another issue that Bertendona intended to remedy. In his opinion, the new galleons did not have any of the flaws observed in the previous series built by Barros in Guarnizo.[224] *San Felipe*, the largest galleon, only drew eight cubits (4.6 m) of water when it was taken out of Portugalete, while *San Simón* and *San Bernabé* had both a draft of only 7.75 cubits (4.46 m). Ojeda expected that the draft of the galleons would not exceed 10 cubits (5.75 m) of water after they were fully laden with all the artillery, provisions, and infantry.[225]

Problems with the masts of the other galleons in Santander

After the departure of the galleons, Riva Herrera recovered the cables and anchors left behind by *San Pablo* and *Santo Tomás,* and sent them on a *zabra* (*small boat*) to El Ferrol. Riva Herrera was in favor of leaving the remaining three galleons unmasted if they were to winter in Santander. The masts could be stored in a shed to keep them dry; the largest ones could be payed with bitumen, and, if necessary, also covered with tarred canvas to protect them from the elements. The galleons could be masted very rapidly in spring just before departing to serve in the Armada of the King.[226] Riva Herrera considered that careening, or even breaming, of the galleons was an

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[224] AGS GYM Leg. 322 doc. 109; AGS GYM Leg. 322 doc. 112.
[225] AGS GYM Leg. 322 doc. 120; AGS GYM Leg. 322 doc. 122.
[226] AGS GYM Leg. 322 doc. 79.

unnecessary waste of time and money because there was no shipworm (*broma*) infestation in the Bay of Santander. It would be better to careen them in March of the following year, just before the galleons were to depart for El Ferrol. In Riva Herrera's opinion, the galleons only needed to have their weather deck (upper deck) and upper works caulked to prevent any rain damage. The remaining masts could be shaped in 30 days, and Vasco Rodríguez could then leave because there was no more work to be done in Santander.[227]

In contrast, Vasco Rodríguez thought that the galleons should be careened and masted if they were to spend the winter in Santander, because they had spent almost three years in the water, and he was concerned about waterlogging of the hull planking. He thought that work on all the galleons would be completed in 15 days.[228] This time, according to Rodríguez, the masting of the galleons was to be carried out in the same way as for the *naus* of India, which he considered more appropriate for the size of the vessels.[229] The previous three galleons had been masted in a different way because the local master carpenters were inexperienced in masting such large vessels.[230] In any case, although the remaining three galleons were being masted as Vasco Rodríguez suggested, the masts were still too high because they had been made in the same way as the others.[231] Riva Herrera rejected the criticism about the quality of the masts fitted in the galleons of Santander, citing the opinions of Vasco Rodríguez himself, Pantaleón

[227] AGS GYM Leg. 322 doc. 79.
[228] AGS GYM Leg. 322 doc. 98; AGS GYM Leg. 322 doc. 100.
[229] AGS GYM Leg. 322 doc. 98; AGS GYM Leg. 322 doc. 99.
[230] AGS GYM Leg. 322 doc. 99.
[231] AGS GYM Leg. 322 doc. 99.

González, and Antonio Franco, who had previously approved the work done in Santander.[232]

Following Bazán's criticism about the masts of the three galleons, the King ordered Riva Herrera to discontinue the masting of the three remaining galleons in Santander. By the time Riva Herrera received the letter of the King on June 24, however, the masts for the remaining three galleons were almost completed, and all the experts seemed to agree on their superior quality. The master carpenters who made the masts had broad experience in making masts, not only in Cuatro Villas (Cantabria) and Biscay but also in France, Flanders, Andalusia, and Malaga. With respect to the slackened rigging of the new galleons, Riva Herrera said that it had to be tightened in El Ferrol because in Santander they had no time for this task due to the need to rapidly prepare and deliver the other remaining galleons. Riva Herrera could not understand or accept the criticism about the masts when even the masters that came from El Ferrol, including Vasco Rodríguez, had not complained about them before.[233]

The other three galleons depart from Portugalete

Ojeda also received a letter from the King ordering him to halt the masting of his galleons due to Bazán's complaints about the masts on Riva Herrera's galleons, and asking Ojeda if it would be convenient to careen the three galleons that were to winter in Portugalete. Ojeda replied that all his masts had been made by experienced master

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[232] AGS GYM Leg. 322 doc. 79.
[233] AGS GYM Leg. 323 doc. 79.

carpenters who had observed how ships were masted in Lisbon, and decided to mast the galleons of Portugalete in the same manner. Nevertheless, Ojeda stopped the work until the master carpenter sent by the King arrived in Portugalete to inspect the masts, although Ojeda doubted that he would find any flaw to be corrected. On the other hand, Ojeda complained to the King because Riva Herrera did not send the remainder of the mast timbers, apart from the 109 spars previously received, thus Ojeda had to cut some local pines and oaks to make the heels for the masts. Ojeda agreed to careen the galleons that were to winter in Portugalete to limit any potential shipworms (*broma*) damage, with the work to begin in mid-September. On July 5, Bertendona finally departed for El Ferrol with the three new galleons and his own ships. After Bertendona sailed the galleons out of the Portugalete sandbar, the ships encountered a severe storm that, fortunately, did not damage the galleons, and the weather improved for the remainder of the voyage.[234]

Ojeda informed the King on July 12 that the remaining three galleons would be ready to sail at the end of September. The sails were already made, and he only needed a small amount of cordage that would arrive with the rest of the 600 hundredweights (*quintales*) of rigging that Lezama still owed him. Vasco Rodríguez had arrived in Portugalete to examine the work done with the masts, and he was so satisfied with the results that he recommended making the masts in the same way for the galleons in Santander. *San Tadeo*, the smallest of the three galleons, was already masted when

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[234] AGS GYM Leg. 323 doc. 88.

Ojeda received the King's letter with the orders to stop the work. Ojeda though that the galleons could be taken downstream to Portugalete in 12 to 15 days. He did not intend to carry out any more work related to the masting of the galleons until the King ordered it. In addition, Ojeda still needed more spars to make all the masts required for the galleons, and asked to be sent the surplus of spars that Riva Herrera had in Santander.[235]

The Armada in El Ferrol

Meanwhile, in El Ferrol, the foremasts and bowsprits of *San Pablo* and the other galleons were being re-stepped and rigged after being repaired.[236] Urquiola thought that it would be impossible to determine accurately the fully laden draft of the galleons, and verify that their gunports were sufficiently clear of sea level, until the galleons were completely loaded with ordnance, ammunition, victuals, and soldiers' equipment.[237] In addition, the galleons brought by Urquiola also needed artillery that was to be provided by the foundry in Lisbon. Two flyboats (*filibotes*) were dispatched from Lisbon, each carrying 15 new pieces of artillery (half of them cannon and the other half culverins), along with 30 shots for each piece, carriages for the guns, and associated tackle.[238]

In general, the galleons had arrived in El Ferrol sorely lacking in equipment and provisions.[239] Bazán designated the newly built *San Pablo* as the *Capitana* (Admiral) of the Armada, as the outfitting of the other galleons continued. In addition, it was

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[235] AGS GYM Leg. 323 doc. 90.
[236] AGS GYM Leg. 322 doc. 49.
[237] AGS GYM Leg. 322 doc. 62.
[238] AGS GYM Leg. 323 doc. 1; AGS GYM Leg. 323 doc. 15.
[239] AGS GYM Leg. 323 doc. 37.

necessary to make special wheels for the gun carriages, since the gunports of the new galleons were located at different heights above the main deck.[240] *San Pablo* was outfitted with all the artillery that it required, although the other ships of the Armada were insufficiently armed, as not all the vessels carried the required number of guns. This was a significant disadvantage for Spanish naval warfare, taking into account the new tactics employed by the enemy that were based on the intensive use of gunfire from a distance rather than boarding tactics.[241]

According to Urquiola, the best of the three new galleons was *San Pablo,* whose gunport (*portas*) locations allowed the use of artillery in any kind of weather and sea conditions. However, the central gunports of the galleons *San Andrés* and *Santo Tomás* were too low, and had to be closed in rough weather and fresh wind to prevent taking on water. In order to remedy this situation, the ballast was to be adjusted with well-distributed small stones, the ships' mainmasts had to be shortened, and their central gunports reshaped because of their closeness to the sea. Bertendona finally arrived in El Ferrol on July 13, with *San Felipe*, *San Simón*, and *San Bernabé*. In Urquiola's opinion, their masts presented the same flaws as those of the galleons of Santander because they were not shaped and fitted properly. The largest galleons, *San Felipe* and *San Simón,* had their gunports located at the right height above sea level, while the gunports of *San Bernabé* were placed too low, as were those of *Santo Tomás* and *San Andrés*.[242]

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[240] AGS GYM Leg. 323 doc. 89.
[241] AGS GYM Leg. 323 doc. 39.
[242] AGS GYM Leg. 323 doc. 45.

However, it was the galleon *San Simón* that presented the greatest challenge because it was leaking heavily when it arrived at El Ferrol; it was decided, therefore, that *San Simón* would not sail with the rest of the Armada until it was fully repaired.[243] With respect to the three galleons that were still in Santander and Zorroza, Urquiola recommended careening them to preserve the planking and the hemp caulking between the planking seams, and to protect the hull from shipworm damage. If the ships were not careened before winter, he warned they would be damaged below the waterline.[244]

Despite the comments of Ojeda defending the quality of the masts of his galleons, they were also criticized by Bazán as soon as Bertendona arrived with them in El Ferrol. In his opinion, the masts had as many flaws as those of the galleons built by Riva Herrera, especially since Ojeda's galleons had also arrived slightly damaged (*sentidos*) from the journey. Although the masts of *San Felipe* and *San Bernabé* were quickly repaired and the ships incorporated into the Armada, *San Simón* required major repairs due to its heavy leaking.[245] The Armada finally departed from El Ferrol without *San Simón* on Monday, August 12, heading for the Azores to escort the returning Indies fleet of that year.[246]

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[243] AGS GYM Leg. 323 doc. 46.
[244] AGS GYM Leg. 323 doc. 45.
[245] AGS GYM Leg. 323 doc. 35.
[246] AGS GYM Leg. 324 doc. 84; AGS GYM Leg. 341 doc. 208; AGS GYM Leg. 323 doc. 263; AGS GYM Leg. 341 doc. 204; AGS GYM Leg. 341 doc. 204; AGS GYM Leg. 341 doc. 205; AGS GYM Leg. 341 doc. 206; AGS GYM Leg. 341 doc. 211; AGS GYM Leg. 341 doc. 188.

The completion of the remaining galleons

By the end of July, the King gave Ojeda permission to resume the fitting of the masts of the galleons that were still anchored in Zorroza. *San Tadeo* was already masted, but Ojeda preferred to take the other two galleons to Portugalete before masting them. In his opinion, it would be safer to take them downstream without masts, and that it would be much easier and faster to complete the outfitting in Portugalete. However, there was still the need of spars to make the masts, and Ojeda asked Riva Herrera to send him any surplus left in Santander. Ojeda also intended to begin the careening of the galleons in October, to prepare them for sailing whenever it was required.[247] The initial plan was that the galleons were to depart from Portugalete by June of 1592.[248]

Figure 14. Location of the port of Pasajes (Gipuzkoa) (modified from Google Earth Pro satellite maps).

[247] AGS GYM Leg. 324 doc. 105.
[248] AGS GYM Leg. 326 doc. 126; AGS GYM Leg. 327 doc. 181 with AGS GYM Leg. 326 doc. 126.

After the return of the Armada to El Ferrol, the King ordered Urquiola to take the galleon *San Simón* to the port of Pasajes (Guipúzcoa) to winter, along with the remaining six Apostles that were still in Santander and Portugalete (Figure 14). Bazán, however, warned the King about the risks of executing this order due to the dangerous entrances of these ports. He also recommended leaving the galleons in Portugalete until the following spring because the winter tides did not allow taking the galleons fully laden over the sandbar.[249] Urquiola was to bring with him a dozen large and medium-sized pine spars to correctly mast the galleons left in Santander and Portugalete. Urquiola also recommended waiting until mid-March to sail the galleons from Portugalete. The King accepted Urquiola's recommendations, although he did order Urquiola to take the galleons from Santander to Pasajes.[250] However, the galleons in Santander had yet to be masted as per the order of the King to halt their outfitting. Thus, they had to winter there, as they lacked sufficient spars to make all the masts that were required. Additionally, the ships had to be caulked because they had spent two years in the inlet. Riva Herrera thought that if he received the rigging and the funds needed to outfit and caulk the galleons, the galleons could depart from Santander by the beginning of next summer. Riva Herrera intended to begin caulking the galleons in January 1592, when he received the materials he needed such as tar (*brea*), hemp (*cáñamo*), fat (*grasa*), and tallow (*sebo*). [251]

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[249] AGS GYM Leg. 327 doc. 13.
[250] AGS GYM Leg. 327 doc. 38.
[251] AGS GYM Leg. 327 doc. 61.

In December, there was a change of plans and *San Simón* was to sail from El Ferrol to Lisbon, while Urquiola would sail to Santander to collect the three new galleons, and from there sail to Pasajes.[252] However, the outfitting of the galleons in Santander was behind schedule, since by the end of December only the mainmast of one of the galleons had been fitted.[253] Nevertheless, Urquiola departed for Santander and Pasajes at the beginning of February of 1592, and arrived in Pasajes on February 15. Unfortunately, Urquiola was unable to enter the Bay of Santander, or even to anchor at El Sardinero, due to bad weather and contrary winds.[254] In fact, Riva Herrera saw Urquiola's squadron passing by the entrance of the Bay of Santander without even signaling or sending a message via a small vessel.[255] It was not until April 11 when Urquiola was finally able to get into Santander to take the new galleons to Pasajes.[256] Between April 20 and 21, Urquiola took the galleons *San Pedro*, *San Juan*, and *Santiago* out of the bay even though the masting of the galleons at the time of their departure was incomplete, and their topmasts were not fitted with yards. Poor weather conditions and the deep draft of the galleons further complicated Urquiola's departure. Despite not being fully laden, *San Juan* ran aground at the entrance of the bay but did not suffer any damage. The galleons finally arrived in Pasajes on April 24, where their masting was completed and the hulls caulked before the ships were commissioned into service.[257]

[252] AGS GYM Leg. 328 doc. 110.
[253] AGS GYM Leg. 328 doc. 94.
[254] AGS GYM Leg. 349 doc. 59; AGS GYM Leg. 349 doc. 82.
[255] AGS GYM Leg. 349 doc. 87.
[256] AGS GYM Leg. 351 doc. 63.
[257] AGS GYM Leg. 351 doc. 111; AGS GYM Leg. 352 doc. 7.

The remaining three galleons built in Deusto were still anchored in Zorroza in November of 1591; in order to take them downstream to Portugalete, they had to wait for the months of good weather and high spring tides. Shipbuilders and shipmasters gathered by the mayor (*corregidor*) of Bilbao to discuss the possibility of taking the galleons out of the sandbar all agreed that it would be impossible at that time of the year due to the contrary winds. Urquiola could not wait for the galleons at sea or in the bay due to the weather, and he was also unable to cross the sandbar to anchor in Portugalete itself. Thus, it seemed better if Urquiola continued on with his journey to Pasajes without stopping in Portugalete and returned for the galleons when they were ready to sail. The other option was for Bertendona, who was going to winter in Portugalete, to take the galleons across the sandbar and escort them to Pasajes.[258] In the end, it was decided to keep the galleons in Zorroza for the winter because it was cheaper and safer to do so than in Portugalete itself. The upper works and decks of the galleons were also caulked to protect them from the rain, before beginning to caulk the hulls. The galleons would be taken to San Nicolás, a place half way downstream, in summer, and from there to Portugalete, as was the tradition in the region to avoid the dangers of the river's sandbanks. One of the galleons, *San Tadeo*, was already masted and anchored in San Nicolás. However, Ojeda refrained from masting the other two in order to take them to Portugalete with greater safety. Since all the masts were stored in Portugalete, the masting of the galleons there could be completed in a month and a half after their arrival.

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[258] AGS GYM Leg. 327 doc. 76.

Concurring with the consensus, Ojeda did not believe that the galleons could be taken over the sandbar in winter due to the bad weather and contrary winds. He thought it be better if Urquiola returned to pick them up when they were ready.[259] The King finally accepted Ojeda's reasoning, and ordered that the galleons stay in Zorroza and San Nicolás during the winter where they would also be careened before transferring to Portugalete in summer. Ojeda further informed the King that he needed money to complete the outfitting of the galleons, along with 150 hundredweights (*quintales*) of rigging, including joined cables (*ayustes*) and cables that Lezama still had to deliver according to the terms of the contract to provide 600 hundredweights (*quintales*) of rigging.[260] The last three galleons built in Deusto, *San Tadeo*, *San Matías*, and *San Bartolomé*, were finally completed in the summer of 1592. Urquiola sailed them out of Portugalete in August, and the galleons arrived safely at the port of Pasajes on August 26, 1592.[261]

[259] AGS GYM Leg. 327 doc. 78.
[260] AGS GYM Leg. 328 doc. 125.
[261] AGS GYM Leg. 355 doc. 187; AGS GYM Leg. 356 doc. 19.

CHAPTER III

DESIGNING THE TWELVE APOSTLES (1588-1590)

When King Philip II ordered Joan de Cardona to organize the construction of a new series of galleons, he only specified the number of ships, their tonnages, and that they were to be designed specifically as warships. The dimensions and design characteristics of the galleons were to be determined by a committee of master shipwrights and naval experts, which included Cristóbal de Barros.[1] Following Barros's advice, Cardona invited 25 shipwrights, shipmasters, and experienced sailors for a meeting in Santander in order to discuss the best design for the new galleons in December 1588.[2] During the meeting, the master shipwrights discussed the ideal deck configuration of the galleons, length, breadth, and depth of hold according to the three sets of tonnages of 500, 600, and 800 tons (*toneladas*) that the King had requested. Once the committee reached an agreement on the dimensions and technical characteristics of the vessels, they prepared a report with their design proposal that Cardona sent to the King.

However, Cristóbal de Barros opposed this proposal arguing that the tonnages of the galleons would be larger than what the King had ordered. Moreover, he calculated the tonnages of the galleons based on the proposed dimensions in order to prove his

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[1] AGS GYM Leg. 244 doc. 267.
[2] AGS GYM Leg. 244 doc. 74.

point to the committee members.[3] According to Barros, the committee members ignored the fact that oceangoing warships had to be longer and wider than merchant vessels because the committee had no experience in the construction of warships. In Barros's opinion, the main dimensions agreed upon for the galleons needed to be reduced proportionally to adjust them to the tonnages dictated by the King. He even suggested consulting the naval experts of Seville because they always provided good technical recommendations, such as during the discussion about the design of the previous series of galleons that Barros built in Guarnizo.[4]

Despite Barros's arguments, Cardona sent the committee's design report to the King without informing Barros about the final dimensions determined for the galleons.[5] The report included the length of keel (*quilla*), hull breadth (*manga*), depth of hold (*puntal*), and deck configuration although there was no mention of the ships' overall lengths (*esloria*) (Table 6).[6] The galleons' main dimensions were expressed in *codos* (cubits) and the tonnages in *toneladas* (tons). However, the proposal did not specify either the type of *codo* or *tonelada* used in the design, although they probably referred to *codo de ribera* and *tonel macho* rather than *codo Castellano* and *tonelada de sueldo*.[7] In

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[3] AGS GYM Leg. 244 doc. 264.
[4] AGS GYM Leg. 244 doc. 264.
[5] AGS GYM Leg. 244 doc. 269.
[6] AGS GYM Leg. 264 doc. 18.
[7] One *codo de ribera* = 0.575 m. One *tonel macho* = 8 cubic *codos de ribera* = 1.52 cubic meters. One *codo de Castilla* = 0.558 m. One *tonelada* (Seville) = 8 cubic *codos de Castilla* = 1.38 cubic meters. One *tonelada* (freight ton) = *tonel macho* or *tonelada* plus 20% - 25%. Casado Soto 1991b, 104.

any case, the King received the committee's proposal at the end of December 1588, less than a month after he ordered the construction of the new galleons.[8]

Table 6. First design of Santander committee. Dimensions are given in cubits (1 cubit = 0.575 m).

SOURCE	**Tonnages** (*Toneladas*)	**Length**	**Keel** (meters)	**Breadth** (meters)	**Floor** (meters)	**Height**				
						Unplanked beams (meters)	**Orlop deck** (meters)	**Main deck** (meters)	**Maximum Breadth** (meters)	**Upper deck** (meters)
1st Design Small Galleons (Dec 1588)	500	-	34 (19.55)	17 (9.77)	-	-	-	10 (5.75)	10-11 (5.75-6.32)	13.75 (7.9)
1st Design Medium-sized (Dec 1588)	600	-	38 (21.85)	18.5 (10.64)	-	-	9 (5.17)	12.5 (7.19)	11-12 (6.32-6.9)	16.25 (9.34)
1st Design Large (Dec 1588)	800	-	42 (24.15)	20.5 (11.79)	-	-	10 (5.75)	13.5 (7.76)	12-13 (6.9-7.47)	17.25 (9.92)

Philip II referred the proposal to the General Álvaro Flores de Quiñones and to Luis César, the Purveyor of the Storehouses and *Armadas* of the Crown of Portugal (*Provedor dos Amazéns e das Armadas da Coroa de Portugal*), asking for their opinion about the design for the galleons due to their naval expertise.[9] Álvaro Flores considered that the dimensions given in the committee's report corresponded to the tonnages of 500, 600, and 800 *toneladas* (tons) ordered by the King. However, he suggested an increase of the galleons' breadths, and a revision of the keel lengths because they were too long, although he himself did not provide any measurement. Moreover, he recommended that the galleons should have wider bows and a tumblehome of 2.5 cubits (1.44 m) at the

[8] AGS GYM Leg. 264 doc. 17.
[9] AGS GYM Leg. 264 doc. 17.

level of the upper deck because that strengthened the hull and improved the ships sailing capabilities especially when receiving the sea and wind from abeam. The report also included comments about the need for having hatches on the upper deck with wooden gratings[10] to ventilate the gunpowder smoke of the artillery on the main deck during combat.[11]

Luis César, on the other hand, provided a more detailed design proposal than Flores, which included most of the main dimensions and several construction details for the 500- and 600-ton galleons. However, César provided the dimensions for the ships in Portuguese *rumos* and *palmos de goa* (goa palms) instead of Spanish *codos* (cubits).[12] César also advised the King that with his dimensions the galleons would become slightly larger than expected because the Portuguese *toneladas* (tons) were larger than the Castilian and Biscayan tons.[13] In fact, the breadths of both of César's galleons were nearly identical to the designs that the Santander committee and Barros proposed for the large Apostles. César also included in his proposal the lengths of the galleons' floors, the heights and rakes of the stem and sternposts, and even the lengths of the wing transom. However, he did not indicate the height of the ships' breadth, or the rake of the stem for

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[10] Steffy (1994, 272) defines grating as a latticework hatch cover used for light and ventilation. The term is also applied to define the lattice work deck in the heads of large ships.
[11] AGS GYM Leg. 264 doc. 20.
[12] 1 *rumo* = 2 *goas* = 6 *palmos de goa* (1.540 m), *Goa* = 3 *palmos de goa* = ½ *rumo* (770 m), *Palmo de goa* = 1/3 *de goa* = 1/6 *rumo* (0.256 m), 1 Portuguese *tonel/tonelada* = 2 *pipas* = 1.611 cubic meters, see Lavanha and Barker 1996, 108; In his report, César (AGS GYM Leg. 264 doc. 19) indicates that the length of the 500-ton galleon is 16 *rumos*, which equals *120 palmos de goa*. His conversion, however, must be incorrect because in that case, the keel length of the 500-ton galleons would be longer that the keel of the 600-ton vessels.
[13] AGS GYM Leg. 264 doc. 19.

the 600-ton galleon and, therefore, it is impossible to calculate the ship's length correctly. Moreover, the report does not mention the height of the upper deck, and is not explicit with respect to the configuration of the upper works (Table 7).[14]

Table 7. Luis César proposal. Units given in *palmos de goa* (1 *palmo de goa* = 0.256 m).

SOURCE	Tonnages (*Toneladas*)	Rake Stem (meters)	Keel (meters)	Rake Sternpost (meters)	Breadth (meters)	Floor (meters)	Height		
							First deck (meters)	Second deck (meters)	Upper deck (meters)
Luis César 500-ton (Jan 1589)	500	30 (14.64)	16 *rumos* (24.64)	10 (2.56)	43 (11.08)	14 (3.58)	15 (3.84)	22.5 (5.76)	-
Luis César 660-ton (Jan 1589)	600	-	18 *rumos* (27.72)	12 (3.07)	46 (11.78)	15 (3.84)	16 (4.1)	24 (6.14)	-

Philip II sent Flores's and Cesar's reports to Cardona for examination by shipwrights of the Santander committee.[15] In his letter, the King also suggested that there was no need to wait for Barros to examine the report because he was in Guipúzcoa, and the wait would delay the verdict of the committee. After examining the reports, Cardona informed the King that there were no major differences between the dimensions suggested in the reports and those of the committee's proposal. The main difference was related to the increase in the ships' breadth that, according to Cardona, had already been corrected. The King accepted Cardona's explanations and decided that there was no need to make additional changes to the designs of the galleons that were agreed upon.[16]

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[14] AGS GYM Leg. 264 doc. 19.
[15] AGS GYM Leg. 264 doc. 17.
[16] AGS GYM Leg. 244 doc. 71.

However, a few days later Barros asked the King about the final decision with respect to the dimensions and designs of the new galleons because Cardona had not yet informed him. Barros still believed that the galleons were designed as merchant vessels rather than as warships, with larger tonnages than the King had requested.[17] His concern was confirmed by Hernando de la Riva Herrera, who had been placed in charge of constructing six of the Apostles at the shipyard of Guarnizo. According to the measurements Riva Herrera had received to construct the galleons, the tonnages of the ships would be larger than the initially planned 500, 600, and 800 tons.[18] In fact, after laying the keel of *San Pedro*, one of the largest galleons, Riva Herrera realized that it was to become even larger than the Portuguese galleon *San Martin*, the flagship of the Armada. However, he also believed that, despite its size, *San Pedro* would have a shallower draft than the previous galleons that Barros built in Guarnizo.[19]

When Barros was finally able to examine the committee's design proposal, he complained that it did not include the overall lengths of the ships, and argued that it would be impossible to verify their tonnages without knowing their lengths. Moreover, the ship lengths also served to determine if the galleons were conceived as warships or merchant vessels. According to Barros, warships required longer lengths than merchantmen, and he was convinced that the dimension of the committee's report corresponded to those of merchant vessels. Barros then prepared an alternative proposal

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[17] AGS GYM Leg. 244 doc. 269.
[18] AGS GYM Leg. 245 doc. 31.
[19] AGS GYM Leg. 245 doc. 32.

with three different sets of dimensions and construction details for the new galleons (Table 8).[20] In his report, Barros clearly specified *codo de ribera* (shipyard cubit) as the linear unit used for the main dimensions of the galleons. He also mentioned that this *codo* was traditionally used in the Canal of Bilbao, Biscay, and equaled ⅔ of a Castilian *vara* (yard) plus one *dedo* (finger), or a total of 33 fingers (*dedos*) (0.575 meters).[21]

Table 8. Barros proposals for the galleons. Dimensions given in cubits (1 cubit = 0.575 m).

SOURCE	**Tonnages** *Toneles* (*Toneladas*)	**Length** cubits (meters)	**Keel** cubits (meters)	**Breadth** cubits (meters)	**Height**				
					Unplanked beams cubits (meters)	**Orlop deck** cubits (meters)	**Main deck** cubits (meters)	**Maximum Breadth** cubits (meters)	**Upper deck** cubits (meters)
Small Galleons (Feb 1589)	702 (842)	48 (27.6)	36 (20.7)	17 (9.77)	4 (2.3)	7.25 (4.17)	11 (6.32)	11 (6.32)	14.75 (8.48)
Medium Galleons Merchant (Feb 1589)	719 (863)	55.5 (31.91)	38 (21.85)	18.5 (10.64)	4.5 – 5 (2.59 – 2.87)	-	12.5 (7.19)	12.5 (7.19)	16.25 (9.34)
Medium Galleons Warships (Feb 1589)	866 (1093)	62 (36.65)	38 (21.85)	18.5 (10.64)	4.5 – 5 (2.59 – 2.87)	-	12.5 (7.19)	12.5 (7.19)	16.25 (9.34)
Large Galleons Merchant (Feb 1589)	985 (1182)	61.5 (15.74)	42 (24.15)	20.5 (11.79)	5 - 5.5 (2.87 – 3.16)	-	13.5 (7.76)	13.5 (7.76)	17.25 (9.92)
Large Galleons Warships (Feb 1589)	1193 (1422)	70 (40.25)	42 (24.15)	20.5 (11.79)	5 - 5.5 (2.87 – 3.16)	-	13.5 (7.76)	13.5 (7.76)	17.25 (9.92)

Barros calculated the ships' tonnages based on his proposed dimensions and also on the ones in the committee's report in order to compare them. He was an expert ship

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[20] AGS GYM Leg. 264 doc. 24.
[21] Casado Soto 1991b, 103-4.

surveyor, and had been surveying ships on the Cantabrian coast since 1563 on behalf of Philip II. Moreover, his survey method and arithmetic formula also became the standard system to gauge ships in 1590, when the King appointed him as the official surveyor in charge of revising all surveys and tonnage calculations for his Armadas.[22] In his report, Barros proved that, according to the dimensions that the committee had proposed, the new galleons would become larger than initially stipulated. He calculated the volumes of the ships in *toneles machos* and *toneladas* in which one *tonelada* equaled one *tonel macho*, or eight cubic *codos*, plus 20% of that volume (Table 8). The additional 20% included the spaces above a vessel's main deck and upper structures, and was a bonus for the ship's owners to add to the basic hiring rates paid by the crown.[23]

Barros also believed that the deep draft of the large- and medium-sized galleons would prevent them from crossing the sandbar of Sanlúcar de Barrameda, at the mouth of the Guadalquivir River. He was against the idea of expanding the widths of ships' floors to reduce their draft because that would only exacerbate the problem. Instead, he suggested to build the four largest galleons based on the dimensions and characteristics of the galleass *San Cristóbal,* which he built in Guarnizo in 1578. His proposal included several construction details for the galleons such as the dimensions and location of the gunports, capstan, and bitts. He even suggested placing openings in the bow and stern to

[22] Casado Soto 1988, 84-90, 113.
[23] AGS GYM Leg. 372 doc. 184; AGS GYM Leg. 373 doc. 37; Casado Soto 1991b, 102-4.

illuminate the interior of the hull during construction, and to ventilate the ship's hold when moored at port.[24]

Philip II sent Barros's proposal to Cardona suggesting that the committee should meet again to discuss the dimensions of the galleons and the deck configuration to adjust them to the ships' original tonnages, and to ensure that they were designed as warships.[25] A meeting was scheduled in Santander with the same experts who had previously agreed upon the initial galleon dimensions, including other shipbuilders and mariners who were at that time in the city. After the evaluation of Barros's report, the committee decided to maintain their initial proposal even if the galleons became larger than expected. Riva Herrera calculated again the tonnages of the ships, and told the committee that, despite the ships being larger than originally planned, they would still have shallower drafts than Barros's previous galleons. Cardona then ordered Riva Herrera to resume the construction of the galleons following the committee's specifications.[26]

After the meeting in Santander, Cardona explained to the King the committee's decision and criticized Barros's attitude during the whole design process of the new galleons.[27] According to Cardona, the report that Barros sent to the King was exactly the same as the one that he had presented to them during the first meeting in Santander, and was rejected because of its misconceptions. Thus, it was decided to follow the first design specifications of the committee that Cardona had sent to the King. The first

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[24] AGS GYM Leg. 264 doc. 24.
[25] AGS GYM Leg. 264 doc. 23.
[26] AGS GYM Leg. 245 doc. 33; AGS GYM Leg. 245 doc. 7.
[27] AGS GYM Leg. 245 doc. 7.

proposal had not included the galleons' lengths and other technical details because the committee considered them too obvious to be mentioned in the report.[28] This time Cardona sent to the King a full design report, which included all the dimensions of the galleons, their tonnages in *toneles machos* and *toneladas*, and other construction details (Table 9).

Table 9. Second design of the Santander committee. Units given in cubits (1 cubit = 0.575 m).

SOURCE	**Tonnages** *Toneles* (*Toneladas*)	**Length** cubits (meters)	**Keel** cubits (meters)	**Breadth** cubits (meters)	**Floor** cubits (meters)	**Height**				
						Unplanked beams cubits (meters)	**Orlop deck** cubits (meters)	**Main deck** cubits (meters)	**Maximum Breadth** cubits (meters)	**Upper deck** cubits (meters)
Small Galleons (Feb 1589)	574 (688)	54 (31.05)	34 (19.55)	17 (9.77)	-	<4 (< 2.3)	6.5 (3.74)	9.5 (5.46)	10.5 (6.04)	13.25 (7.62)
Medium Galleons (Feb 1589)	742.75 (891)	59 (33.92)	38 (21.85)	18.5 (10.64)	-	+/- 4 (+/- 2.3)	8 (4.6)	11.5 (6.61)	12.5 (7.19)	15 (8.62)
Large Galleons (Feb 1589)	974 (1159)	64 (36.8)	42 (24.15)	20.5 (11.79)	7 (4.02)	Scarfs	9 (5.17)	12.5 (7.19)	13.5 (7.76)	16 (9.2)

The final report was divided into two columns comparing Barros's and the committee's proposal. The comparative analysis involved the deck configuration, references to the dimensions and characteristics of the previous galleons designed by Barros and the galleass *San Cristóbal*, and their design flaws and tonnages. The committee of shipwrights admitted in the report that, according to their dimensions, the new galleons were to become slightly larger than initially planned. However, their

[28] AGS GYM Leg. 245 doc. 7.

proportions and moulds would ensure a shallow draft and good sailing capabilities, especially when close-hauled or running downwind. In Cardona's opinion, any experienced shipwright or shipmaster would agree upon the committee's proposed design, and any modification to those specifications would result in an undesirable deeper draft.[29] Moreover, in the opinion of those with naval warfare experience, the galleons would be excellent warships, and it was impossible that the best shipwrights of Spain were so mistaken in relation to their design. Cardona also said that Barros did not understand the committee's design because he had never sailed or experienced naval combat. The King finally approved that the galleons were to be built according to the committee's proposal although he advised Cardona to try to maintain their initial tonnages.[30]

The main dimensions of the Twelve Apostles

The examination of the design reports of the Santander committee and Cristóbal de Barros reveals minor differences between the main dimensions proposed for the galleons. The main dimensions included in the design proposals were the lengths of the ships (*esloria*),[31] keel lengths (*quilla*), breadths (*manga*), depths of hold (*puntal*), deck configuration, and the height of the galleons' maximum breadth or width (*lo más*

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[29] AGS GYM Leg. 245 doc. 11.
[30] AGS GYM Leg. 245 doc. 7.
[31] This dimension corresponds to the length of the ship between perpendiculars.

ancho/manga) (Table 10). None of the proposals mentioned the floor lengths, deadrise and narrowing of the frames, or the dimensions and form of the entries and runs.

Table 10. Dimensions of the Twelve Apostles. Units given in cubits (1 cubit = 0.575 m).

SOURCE	**Tonnages** *Toneles* (*Toneladas*)	**Length** cubits (meters)	**Keel** cubits (meters)	**Breadth** cubits (meters)	**Floor** cubits (meters)	**Height**				
						Unplanked beams cubits (meters)	**Orlop deck** cubits (meters)	**Main deck** cubits (meters)	**Maximum Breadth** cubits (meters)	**Upper deck** cubits (meters)
1st Design Small Galleons (Dec 1588)	(500)	-	34 (19.55)	17 (9.77)	-	-	-	10 (5.75)	10-11 (5.75-6.32)	13.75 (7.9)
Barros Small Galleons (Feb 1589)	702 (842)	48 (27.6)	36 (20.7)	17 (9.77)	-	4 (2.3)	7.25 (4.17)	11 (6.32)	11 (6.32)	14.75 (8.48)
2nd Design Small Galleons (Feb 1589)	574 (688)	54 (31.05)	34 (19.55)	17 (9.77)	-	<4 (< 2.3)	6.5 (3.74)	9.5 (5.46)	10.5 (6.04)	13.25 (7.62)
1st Design Medium Galleons (Dec 1588)	(600)	-	38 (21.85)	18.5 (10.64)	-	-	9 (5.17)	12.5 (7.19)	11-12 (6.32-6.9)	16.25 (9.34)
Barros Medium Galleons Merchant (Feb 1589)	719 (863)	55.5 (31.91)	38 (21.85)	18.5 (10.64)	-	4.5 – 5 (2.59 – 2.87)	-	12.5 (7.19)	12.5 (7.19)	16.25 (9.34)
Barros Medium Galleons Warship (Feb 1589)	866 (1093)	62 (36.65)	38 (21.85)	18.5 (10.64)	-	4.5 – 5 (2.59 – 2.87)	-	12.5 (7.19)	12.5 (7.19)	16.25 (9.34)
2nd Design Medium Galleons (Feb 1589)	742.75 (891)	59 (33.92)	38 (21.85)	18.5 (10.64)	-	+/- 4 (+/- 2.3)	8 (4.6)	11.5 (6.61)	12.5 (7.19)	15 (8.62)
1st Design Large Galleons (Dec 1588)	(800)	-	42 (24.15)	20.5 (11.79)	-	-	10 (5.75)	13.5 (7.76)	12-13 (6.9-7.47)	17.25 (9.92)
Barros Large Galleons Merchant (Feb 1589)	985 (1182)	61.5 (35.36)	42 (24.15)	20.5 (11.79)	-	5 - 5.5 (2.87 – 3.16)	-	13.5 (7.76)	13.5 (7.76)	17.25 (9.92)
Barros Large Galleons Warship (Feb 1589)	1193 (1422)	70 (40.25)	42 (24.15)	20.5 (11.79)	-	5 - 5.5 (2.87 – 3.16)	-	13.5 (7.76)	13.5 (7.76)	17.25 (9.92)
2nd Design Large Galleons (Feb 1589)	974 (1159)	64 (36.8)	42 (24.15)	20.5 (11.79)	7 (4.02)	Scarfs	9 (5.17)	12.5 (7.19)	13.5 (7.76)	16 (9.2)
San Tadeo (Nov 1592)	-	57.66		19.75	-	-	-	10.5	12	-
San Matías (Nov 1592)	-	66.75		21.33	-		-	12.5	13	-
San Bartolomé (Nov 1592)	-	63.25		20	-	-	-	11.08	12.5	-

These basic sets of main dimensions allowed the shipwrights and naval experts to discuss the best design characteristics of ships that were to be built. The dimensions also served to calculate the ship's tonnage in order to verify the correspondence between the dimensions and tonnages determined in the design proposals. Shipwrights used these dimensions and their own experience to determine the shape of the master frame from which the central section of the hull was generated towards the forward and aft tailframes. Geometrical methods such as the half-moon (*mezza-luna*)[32] were then applied to define the narrowing and rising of the hull frames.

The analysis of the three design proposals for the Twelve Apostles showed that the differences between the designs were limited to the lengths of the ships, the heights at which the ships' maximum breadth was located, deck configurations and, in the case of the small galleons, the keel lengths. All the dimensions corresponded to the surveying measurements that were used to calculate the tonnages of the vessels. The sided and molded dimensions of the principal timbers of the vessel, such as the keel, stem and sternpost, or the molded dimension of the main floor were not indicated in the proposals.

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[32] According to Steffy (1994, 97-8), in the half-moon or *mezzaluna* method a vertical line represented the amount of narrowing or rising to be applied to the floor between the master frame and the tailframes. Arcs were traced on both sides of the top of the vertical line to the base which corresponded to the tailframe. Each arc was then divided into the number of frames to be projected, and the points on each arc were joined with horizontal lines. The segments defined by these line when intersecting the main vertical lines corresponded to the narrowing or rising increment for each successive frame. See also Steffy 1994. Fig. 4.22.

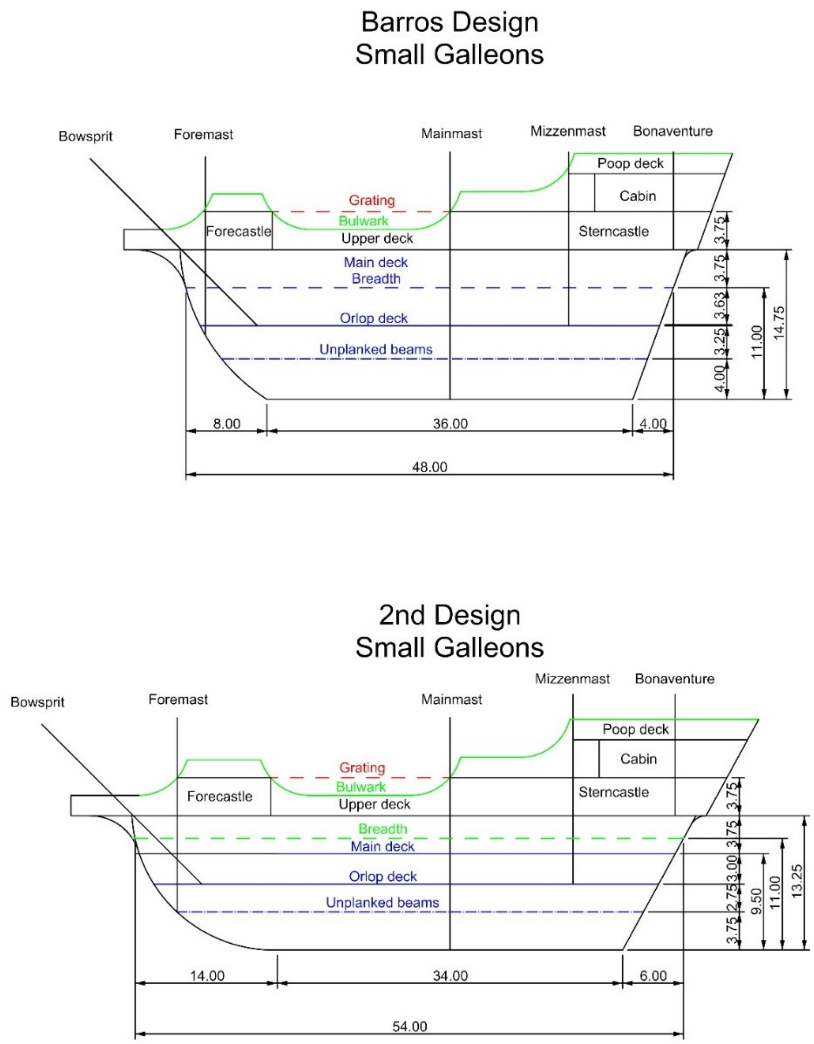

Figure 15. Longitudinal section of small galleons (drawing by J. Casabán).

*The keel (*quilla*)*

The length of the keel is the first primary dimension that appears in the three design reports prepared by the Santander committee and Barros. The keel is the main timber of a ship, forming the backbone of the hull.[33] In the case of the small galleons, the committee of shipwrights proposed a keel length of 34 cubits (19.55 m), while Cristóbal de Barros recommended a keel length of 36 cubits (20.7 m) (Table 10) (Figure 15).[34] For the keel lengths of the medium-size and large galleons, the committee of shipwrights and Barros both provided the measurements of 38 and 42 cubits (21.85 and 24.15 m) (Figures 16 and 17).

The three design proposals defined the length of keel as *quilla limpia* (clean keel). This measurement corresponded to the distance between the inner intersections of the rising of the stem and sternpost, excluding their molded dimensions, with the upper surface of the keel.[35] In his proposal, Barros also mentioned that the 0.5 cubit (29 cm) length of the *zapata* was not included in the length of the clean keel.[36] The interpretation of the term *zapata*, on the other hand, is problematic because Barros did not provide any additional information apart from its dimension.

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[33] Escalante 1985, 39; Palacio 1944, 96.
[34] AGS GYM Leg. 264 doc. 18; AGS GYM Leg. 264 doc. 24; AGS GYM Leg. 245 doc. 11.
[35] Gaztañeta (1720, fol. 1r) refers to the *quilla limpia* (clean keel) as *quilla rigurosa* (rigorous keel); O'Scanlan 1831, 446; Barkham 2007, 5:3.
[36] AGS GYM Leg. 264 doc. 24.

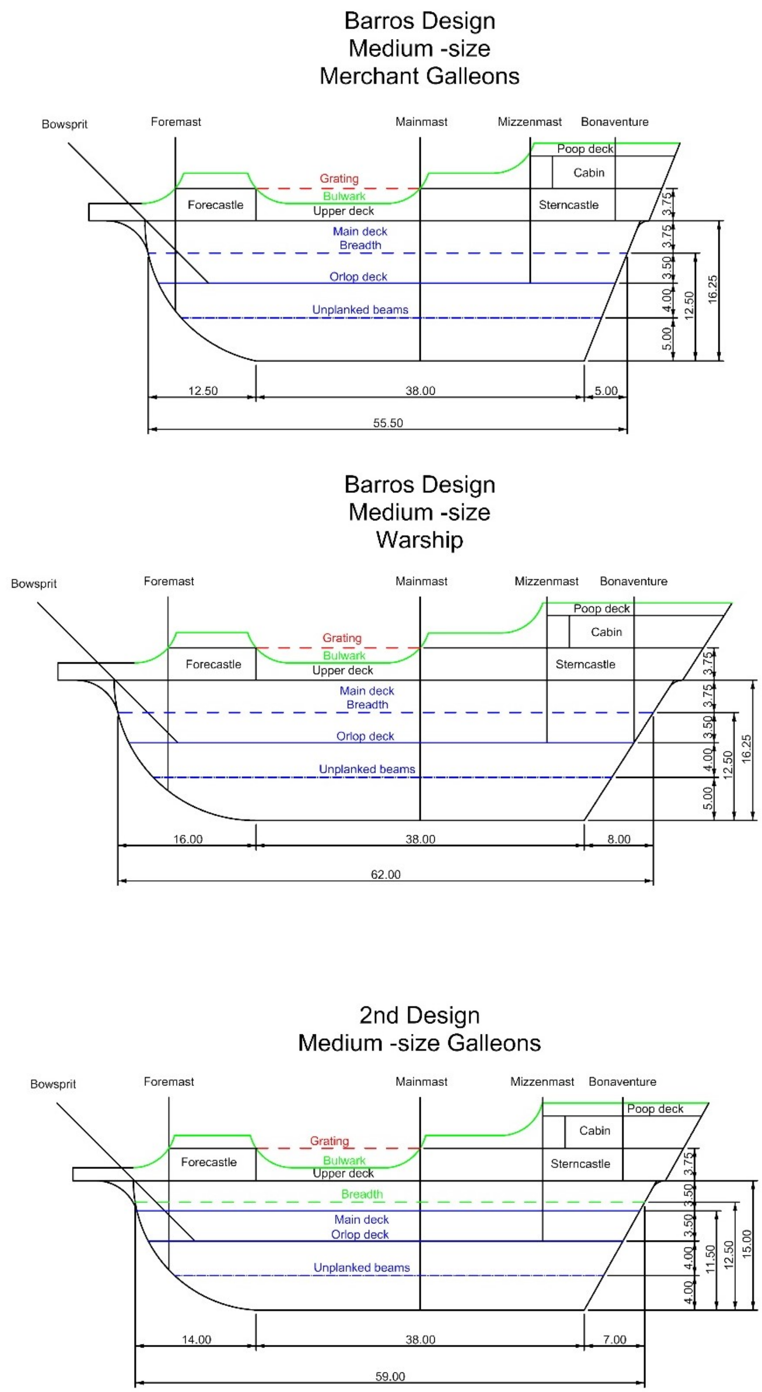

Figure 16. Longitudinal section of the medium-sized galleons (drawing by J. Casabán).

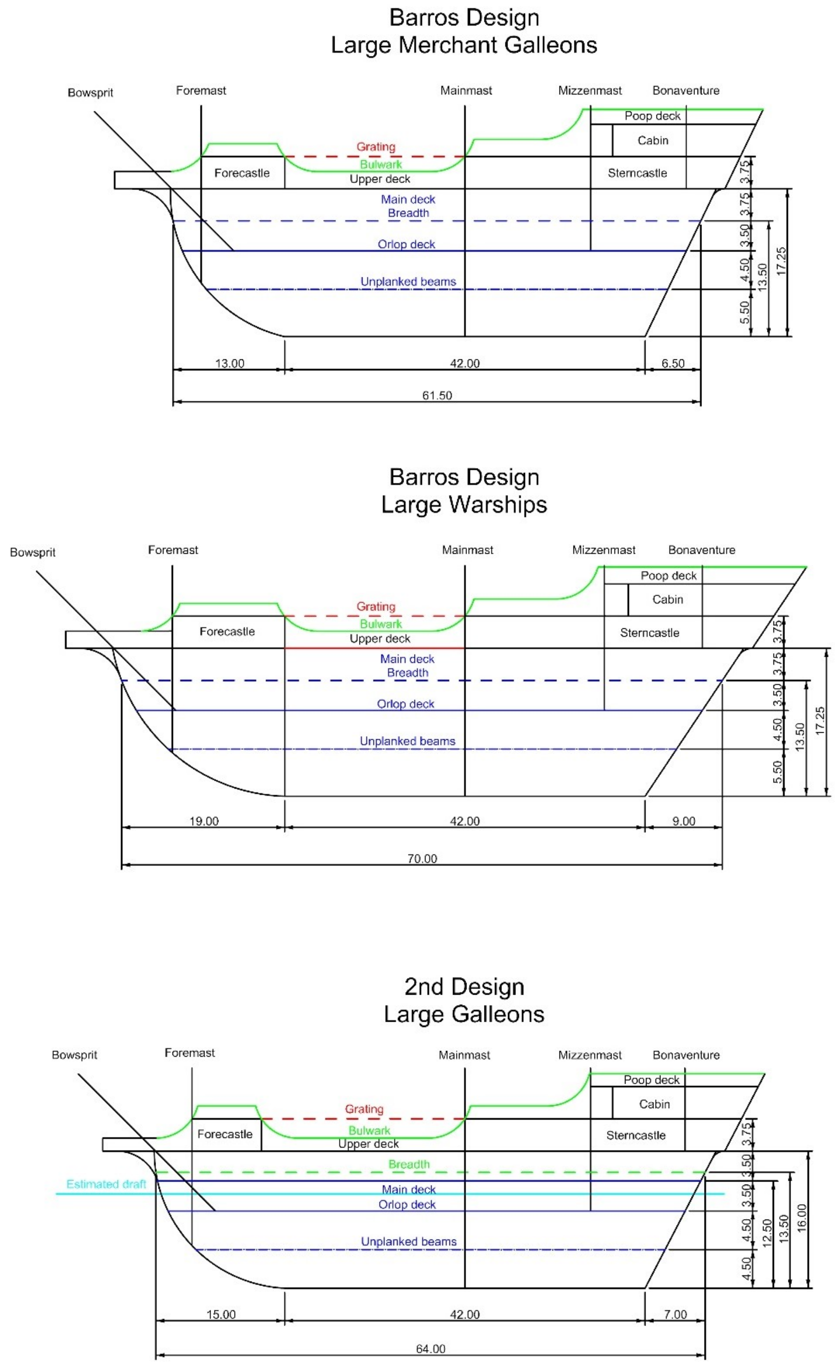

Figure 17. Longitudinal section of large galleons (drawing by J. Casabán).

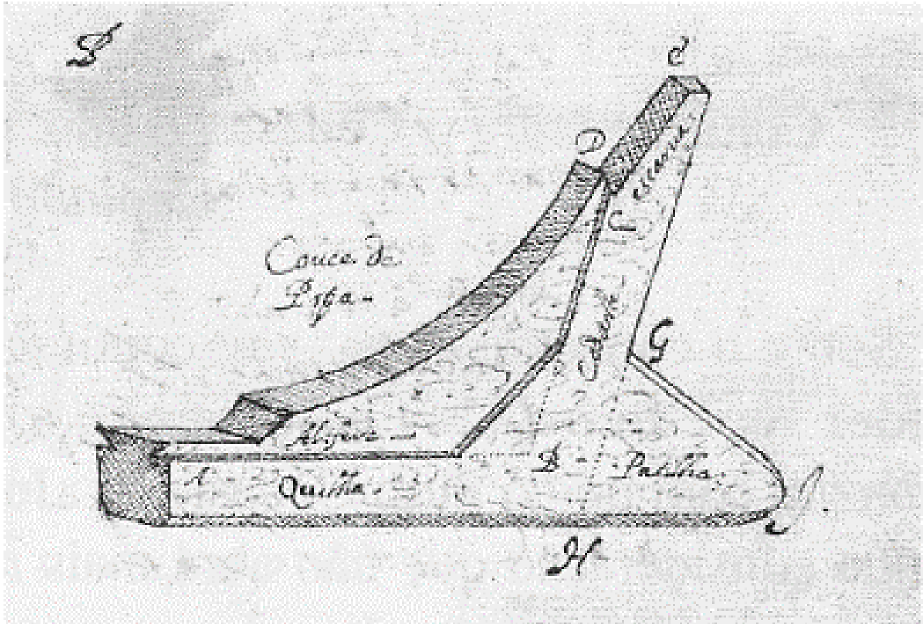

Figure 18. ***Couce de poupa*** **(after Lavanha and Barker 1996, 45, figure 10).**

Loewen has suggested the identification of *zapata* with the heel timber based on 16th-century Guipuzcoan notarial documents.[37] The z*apata,* based on Loewen's interpretation, would then correspond to what Lavanha referred to as *couce de poupa*, the large angular timber that extended the after end of the keel and connected it to the sternpost (Figure 18).[38] This was a typical feature of the 16th-century Iberian-Atlantic shipbuilding tradition that has been documented in nine shipwrecks of that period.[39]

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[37] Loewen (2007, 3:27-41, 42) cites a shipbuilding contract dated to 1573 in Zumaia (Gipuzkoa) which reads: "La quilla aya de ser de una pieza y mas su zapata y branque como a semejante nao combiene." (The keel had to be of one piece plus its heel timber and stem as it corresponds to such a *nao*).

[38] Loewen 2007, 3: 27.

[39] 24M vessel at Red Bay, Loewen 2007, 3:40-3; *San Esteban* at Padre Island, Rosloff and Arnold 1984, 289-92; Studland Bay Wreck, Thomsen 2000, 70-2; Emanuel Point I Wreck, Smith et al. 1995, 34-5; Western Ledge Wreck, Bojakowski 2011, 33-5; Angra D Wreck, García and Monteiro 2001, 439-40; Ria de Aveiro A Wreck, Alves et al. 2001b, 18-9; Corpo Santo Wreck, Alves et al. 2001a, 407-14; *San Diego*, L'Hour 1996, 146-48.

However, Loewen also recommends caution when applying the term *zapata* because O'Scanlan provided other definitions for the term, apart from heel timber, which included the false keel.[40] In fact, another definition of *zapata* included in O'Scanlan's nautical dictionary, and not mentioned by Loewen, is the triangular skeg (*talón*) located at the after end of the keel to protect the rudder.[41]

The main argument against the identification of the term *zapata* as the heel timber in Barros's design report is based on its horizontal length. According to Barros, the dimension of the *zapata* was only 0.5 cubit (29 cm) for all the galleons, irrespective of their keel lengths or tonnage. Moreover, this dimension does not match the measurements of the archaeological remains of the 15th- and 16th-century heel timbers of Iberian vessels (Table 11). The only intact heel timber documented corresponds to vessel 24M excavated at Red Bay. It presents a horizontal length of 1.95 m (3.39 cubits) from the vertical scarf to the keel until to the end of the triangular skeg, which has a length of 36 cm (0.63 cubits). The heel of the Studland Bay wreck has a preserved length of 2.15 m (3.74 cubits), including a 10-15 cm (0.17-0.26 cubits)-long skeg, although the vertical scarf to the keel was not preserved. The heel timber of the other Iberian vessels were also preserved but it was not possible to determine their horizontal length because they were not fully preserved or excavated and, therefore, the scarfs to the keel were not located (Table 11). In any case, the lengths of the preserved heel timbers exceed significantly the length of 0.5 cubits that Barros mentioned in his design report. It is

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[40] Loewen 2007, 3:42; O'Scanlan 1831, 566.
[41] O'Scanlan 1831, 510.

unlikely, therefore, that Barros referred to the heel timber when mentioning the length of the *zapata* in his design reports for the Apostles.

Table 11. **Heel dimensions of Iberian vessels (15th – 16th centuries).**

Wreck	Timber Heel Length (meters)	Skeg Length (cm)	Horizontal		Vertical		*Zapata* Length (Gaztañeta) (cm)	Keel/Heel scarph
			Sided (cm)	Molded (cm)	Sided (cm)	Molded (cm)		
Vessel A Rye	Not preserved	-	-	-	-	-	-	-
24M Red Bay	1.95 m	36 cm	25 cm	26 cm	25 cm	26 cm (0.45 cubits)	58 cm (1 cubit)	Yes (Vertical)
San Esteban	3.5 m preserved (Heel + Keel)	No skeg	31 cm	27 cm	31 cm	24 cm (0.42 cubits)	18 cm (0.31 cubits)	N/A
Highborn Cay wreck	Not preserved	-	15-16.5 cm (keel)	21 cm (keel)	-	-	-	-
Molasses Reef Wreck	Not preserved	-	-	-	-	-	-	-
Cattewater Wreck	Not preserved	-	27-30 cm (keel)	30-34.5? cm (keel)	-	-	-	-
Studland Bay	2.15 m (Preserved)	10-15 cm	16-22 cm	-	-	-	N/A	Not preserved
Emanuel Point I	N/A (partially excavated)	-	20 cm	-	35 cm	25 cm (sternpost) (0.43 cubits)	-	N/A
Ria de Aveiro	N/A	20 cm	12	12	11 cm (sternpost)	-	-	Yes (vertical)
Western Ledge Wreck	Not preserved (only vertical part and stern knee)	Not preserved	17-23 cm (keel)	15-22 cm (keel)	-	-	31.9 cm (0.55 cubits)	Not preserved
San John's Bahamas	-	-	-	-	-	-	-	-
Angra D	N/A (preserved)	No skeg	25 cm	30 cm	-	-	-	N/A
Pepper Wreck	Not preserved	Not preserved	-	-	-	-	-	Not preserved
Cais do Sodre	Not preserved (missing)	-	25 cm (keel)	27 cm (keel)	-	-		-
Corpo Santo	1.4 m (preserved)	0.24 cm	11-12 cm	11-12 cm	5.7-13.5 cm	12 cm (0.21 cubits)	35 cm (0.61 cubits)	Not preserved
San Diego	N/A (partially excavated) (Heel + Keel)	0.29 cm	30 cm (keel)	15+21cm (keel)	-	-	0.69 cm (1.2 cubits)	N/A

While not all the full horizontal lengths of the preserved Iberian heel timbers could be determined, it was still possible in several cases to measure the lengths of their skegs. However, it should be noted that the heel timbers of Angra D and *San Esteban* were shaped without a skeg. In other cases, it was impossible to determine the presence of a skeg since the after end of the heel timbers were not preserved or fully preserved or, in some instances, excavated (Table 11). The horizontal lengths of the preserved skegs ranged between the 10-15 cm (0.17-0.26 cubits) of the Studland Bay wreck and the 36 cm (0.63 cubits) of the 24M vessel at Red Bay. The Corpo Santo wreck had a skeg of 24 cm (0.42 cubits), while the Ria de Aveiro A wreck presented a skeg with a length of 20 cm (0.35 cubits). Interestingly, the skeg of the Spanish galleon *San Diego*, which sank in the Philippines in 1600, measured 29 cm (0.5 cubits), the same length as Barros indicated in his design report for the Apostles (Table 11). Therefore, despite the length variation, there is the possibility that Barros referred to the skeg when he mentioned the *zapata* of the Twelve Apostles. Moreover, skeg (*talón*) is one of the definitions provided for the term *zapata* in O'Scanlan nautical dictionary.

In addition, Gaztañeta provided another definition of the term *zapata* in 1720 that might also correspond to Barros's use of the term. According to Gaztañeta, *zapata* was the after portion added to the "rigorous" keel (*quilla rigurosa/limpia*) where the sternpost was inserted or assembled onto the keel. It was measured from the inner point of intersection of the sternpost with the keel until the end of the keel, including the skeg (Figure 19).[42] According to Barros's documents, this measurement was only 0.5 cubits (29 cm), and independent of the size of the galleon. However, lengths of the *zapatas,* as

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[42] See Gaztañeta 1720, fol. 19v-19r, also in Hormaechea et al. 2012, 1:280.

defined by Gaztañeta, of the aforementioned Iberian heel timbers varied between 18 and 69 cm (0.31 and 1.2 cubits). For instance, the *zapata* of the 24M vessel measured 58 cm (one cubit), *San Diego*'s reached 69 cm (1.2 cubits), and that of the Corpo Santo wreck measured 35 cm (0.61 cubits), although this vessel was smaller than the previous two. The Western Ledge wreck had a *zapata* that measured 31.9 cm (0.55 cubits) although its skeg was not preserved, while the length of the Studland Bay wreck is not available even though had a skeg. *San Esteban*'s *zapata*, on the other hand, measured 18 cm (0.31 cubits) although it did not have a skeg. In the other cases, the lengths of their *zapatas* were not available because the ship's heel timbers were not fully preserved or excavated (Table 11). Regardless, the majority of these measurements exceeds the dimension provided by Barros for the Apostles. However, they are still closer to Barros's dimensions for the *zapata* than the preserved horizontal lengths of the heel timbers measured from the vertical keel scarf to the after end of the skeg.

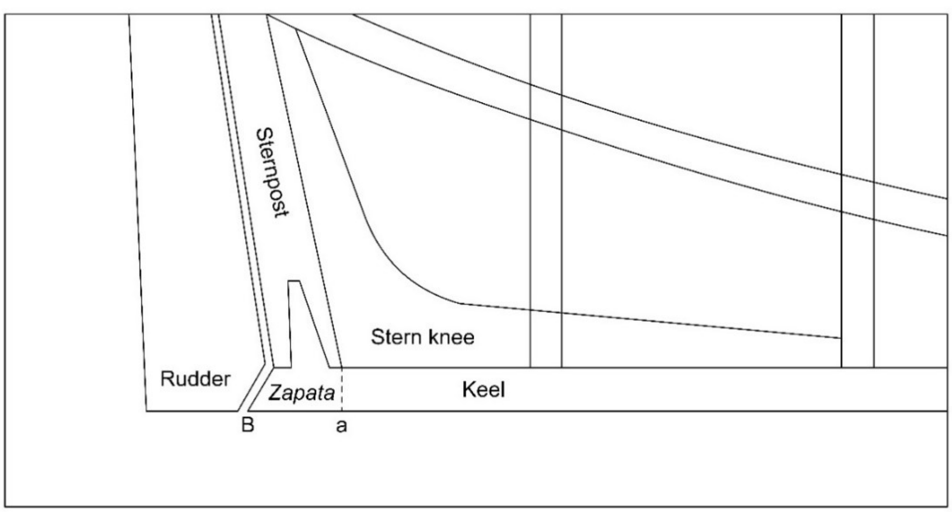

Figure 19. *Zapata*, measured between points B and a (modified from Gaztañeta 1720, *Plano del Navío de 70 Cañones*, page not numbered).

Finally, Gaztañeta also indicated in his 1720 treaty that, at the forward end of the keel, the *zapata* was referred to as *gorja* (gripe), and it was measured horizontally from the inner intersection of the rising curve of the stem with keel until the forward end of the gripe timber (Figure 20). Neither the *zapata* nor the *gorja* were included in the length of the clean keel. [43] Barros also mentioned the *gorja* in his design proposal for the large galleons and in the description of the galleass *San Cristóbal*. In his report, Barros indicated that if the *quilla limpia* (clean keel) of the large galleons did not exceed 42 cubits (24.15 m), the *asiento* (gripe) should measure three cubits (1.73 m) for a total keel length of 45 cubits (25.88 m). In the case of the galleass *San Cristóbal*, Barros mentioned that it had a clean keel, without the *zapata*, of 38 cubits (21.85 m) and an *asiento* (gripe) of four cubits (2.3 m) because it was impossible to find a single timber 42 cubits (24.15 m) long.[44] In both cases, Barros distinguished between the length of the clean keel and the keel that included the forward addition of the *asiento* but not the aft extension of the *zapata*. On the other hand, none of the design reports of the committee included any reference to the *zapata* or *gorja*, and only mentioned the length of the clean keel of the galleons. Gaztañeta's definition of *zapata* is the same as that given by O'Scanlan in his dictionary, in addition to its definition as a false keel and a skeg, although it also referred to it as a gripe.[45]

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[43] Gaztañeta 1720, fol. 26.
[44] AGS GYM Leg. 264 doc. 24, AGS GYM Leg. 245 doc. 11.
[45] O'Scanlan 1831, 566.

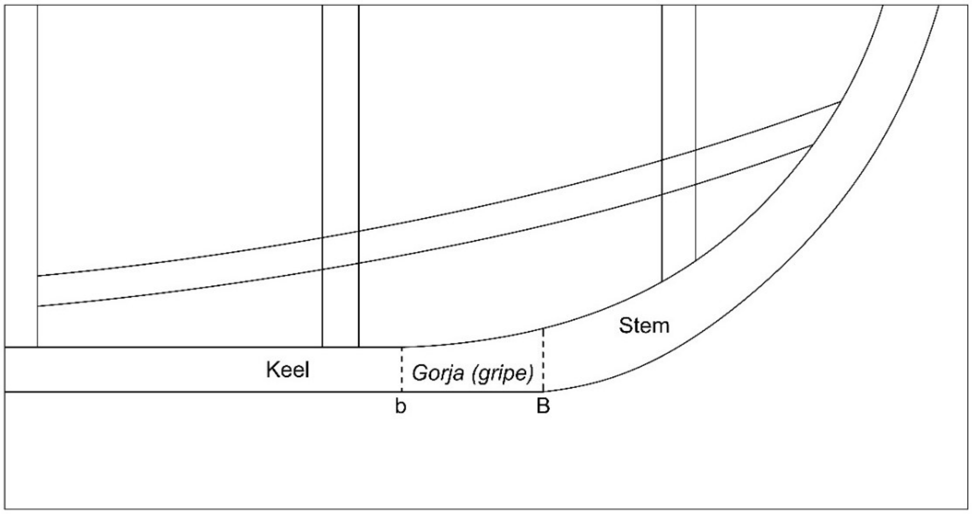

Figure 20. ***Gorja*** **(gripe), measured between points b and B (modified from Gaztañeta 1720,** ***Plano del Navío de 70 Cañones*****, page not numbered).**

*The breadth (*manga*)*

The design reports indicated the ships' breadth, which corresponded to their maximum widths, excluding the thickness of the hull planking. The reports also specified the heights (*puntal/altor*), or vertical distance from the ceiling planking (*granel/soler*), at which the ship's breadth was to be situated.[46] This distance was referred to in the design reports as "height to the widest" ("*puntal/altor a lo más ancho*") or to "the widest of the breadth" ("*lo más ancho de la manga*").[47] It has to be noted that the variations in the height of the ship's breadth affected both the design of the midship

[46] O'Scanlan 1831, 352; BNM Sección de manuscritos n. 1816 fols. 121-123, in Casado Soto 1988, 289; AGS GYM Leg. 117 doc. 98, in Casado Soto 1988, 289, 351; also in Navarrete 1971, 22.1, doc. 76, fol. 322; Escalante (1985, 39) defines the ship's breadth as the width of the vessel measured at the level of the main deck or the deck immediately below the upper deck; According to Steffy (1994, 254), this dimension also refers to the molded breadth.
[47] AGS GYM Leg. 264 doc. 18; AGS GYM Leg. 264 doc. 24, AGS GYM Leg. 245 doc. 11.

section and the tonnage calculations. Moreover, the shape of the master frame dictated the ship's draft and its ballast requirements to ensure stability.[48]

The three design reports for the Twelve Apostles determined the same maximum breadths for each group of galleons according to their different tonnages. The proposals determined a breadth of 17 cubits (9.78 m) for the small galleons, 18.5 (10.64 m) for the medium-sized galleons, and 20.5 (11.79 m) for the largest ones (Table 10). However, the reports also showed differences related to the height at which the ships' breadth, or maximum width, were situated with respect to the main deck and ceiling planking.

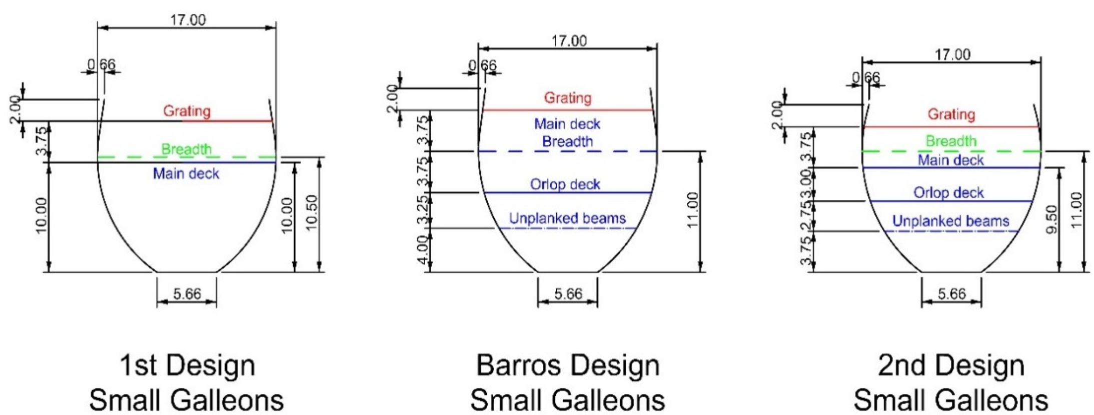

Figure 21. Small galleons, midship sections (drawing by J. Casabán).

In the first report prepared by the committee in Santander, the breadth for the small galleons was located at a height between 10 and 11 cubits (5.75 and 6.33 m), while

[48] Gaztañeta *et al*. 1992, 1:16.

the main deck (*cubierta principal*) was at 10 cubits (5.75 m).[49] In contrast, Barros recommended to place the maximum breadth at a height of 11 cubits (6.33 m), and at the same level as the main deck (*segunda cubierta*).[50] The final report of the committee set the location of the ship's breadth at a height of 10.5 cubits (6.04 m), one cubit (0.575 m) above the main or gundeck (*segunda cubierta de la artillería*), which was lowered by 0.5 cubit (0.29 m) with respect to the original proposal (Table 10) (Figure 21).[51]

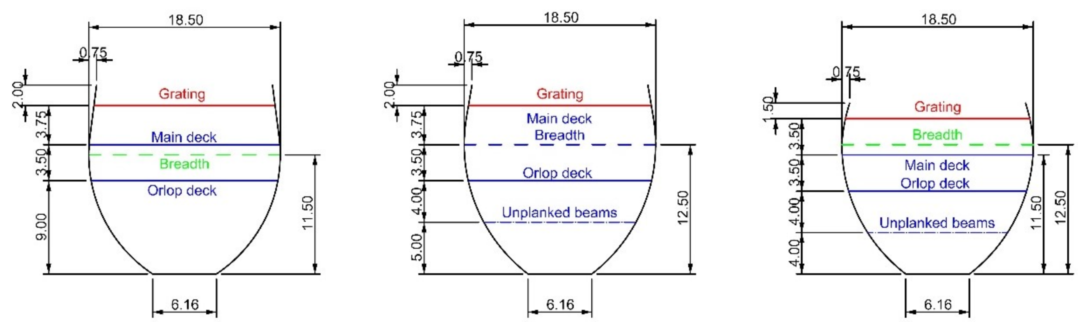

Figure 22. Medium-sized galleons, midship sections (drawing by J. Casabán).

According to the committee's initial report, the height for the breadth of the medium-sized galleons was to be between 11 and 12 cubits (6.33 and 6.9 m), and located below the main deck (*segunda cubierta*), which was situated at 12.5 cubits (7.19 m).[52] In

[49] AGS GYM Leg. 264 doc. 18.
[50] AGS GYM Leg. 264 doc. 24; AGS GYM Leg. 245 doc. 11.
[51] AGS GYM Leg. 245 doc. 11.
[52] AGS GYM Leg. 264 doc. 18.

Barros's report, the widest breadth was situated between 12 and 12.5 cubits (6.9 and 7.19 m) although he preferred a height of 12.5 cubits (7.19 m), and located just at the same level as the main deck (*segunda cubierta o puente*).[53] The final report of the Santander committee also located the breadth at a height of 12.5 cubits (7.19 m) although in this case the main deck (*segunda cubierta*) was at 11.5 cubits (6.61 m), one cubit below the ship's maximum breadth (Table 10) (Fig. 22).[54]

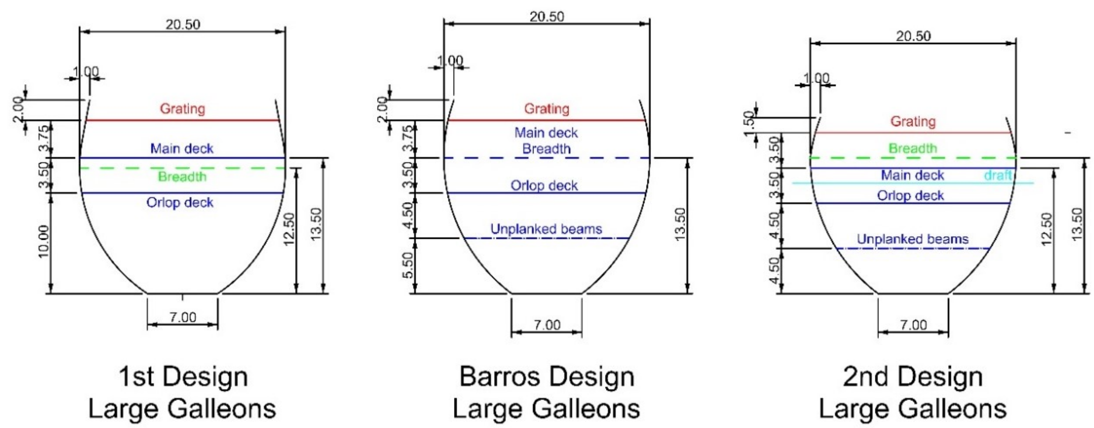

Figure 23. Large galleons, midship sections (drawing by J. Casabán).

The first committee's report listed the maximum breadth of the large galleons between 12 and 13 cubits (6.9 and 7.48 m), while the main deck (*segunda cubierta*) was at 13.5 cubits (7.76 m). Barros placed the ship's breadth at 13 cubits (7.48 m) although he recommended 13.5 cubits (7.76 m), and at the same height as the main deck (*segunda*

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[53] AGS GYM Leg. 264 doc. 24; AGS GYM Leg. 245 doc. 11.
[54] AGS GYM Leg. 245 doc. 11.

cubierta).[55] In the final report, the shipwrights decided the location of the ship's maximum breadth to be at 13.5 cubits (7.76 m), and located at one cubit (0.575 m) above the main deck (*segunda cubierta*), which was set at 12.5 cubits (7.19 m) **(**Table 10) (Figure 23).[56]

The final report of the committee of shipwrights determined that all of the galleons should have their maximum breadth located one cubit (0.575 m) above their main decks (*segundas cubiertas*). This configuration was the opposite to the location that Barros proposed for the breadths of the previous series of galleons built in Guarnizo between 1582 and 1583. In that case, the widest breadth was situated 2 cubits (1.15 m) below the main deck (*cubierta principal*) despite the fact that these galleons had three decks and a row of unplanked beams.[57] However, in the case of the Twelve Apostles Barros recommended to locate the maximum breadth at the same height as the main deck (*segunda cubierta*).

*The length (*esloria*)*

The lengths (*esloria*) provided in the design reports of the Twelve Apostles correspond to the distance between the sternpost to the stem measured at the same level as the ship's maximum breadth.[58] This distance included the rake of the sternpost, the

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[55] AGS GYM Leg. 264 doc. 24; AGS GYM Leg. 245 doc. 11.
[56] AGS GYM Leg. 245 doc. 11.
[57] AGS GYM Leg. 117 doc. 98, in Casado Soto 1988, 351; also in Navarrete 1971, 22.1, doc. 76, fol. 322.
[58] BMN Sección de manuscritos n. 1816 fols. 121-3, in Casado Soto 1988, 289-91; According to Escalante (1985, 39-40), the ship's length (*esloria*) was the distance between the sternpost to the stem of the vessel along the main deck, where the ship's maximum breadth and depth of hold were also measured.

length of the keel, and the rake of the stem.[59] The lengths of the Twelve Apostles are indicated in Barros's proposal and the second design report of the Santander committee while the first report that Cardona sent to the King does not include them.

In his proposal, Barros recommended longer ship lengths than in the committee's final report, except for those of the small galleons. He suggested a length of 48 cubits (27.6 m) at a height of 11 cubits (6.32 m), the same height at which the ship's maximum breadth and main deck (*segunda cubierta*) were situated (Table 10) (Figure 15). The rakes of the stem and sternpost were to be based on the proportions of the previous series of galleons built in Guarnizo although this was not explicitly stated in the proposal. In fact, these proportions were also absent from the designs of the Guarnizo galleons.[60] The committee's final report, on the other hand, specified a length for the small galleons of 54 cubits (31.05 m), six cubits (2.88 m) longer than that in Barros's design, but without any reference to its height with respect to the ceiling planking, or the bow and stern rakes (Table 10) (Figure 15).[61]

For the medium-sized galleons, Barros proposed two different lengths depending on whether they were designed as warships or merchantmen. If the galleons were conceived as warships they required a length of 62 cubits (35.65 m), but only 55.5 cubits (31.91 m) as merchant ships. In this instance, Barros did not indicate the height at which the ship lengths were to be measured although it probably coincided with the height

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[59] O'Scanlan 1831, 258; Palacio 1944, 92; Steffy 1994, 253.
[60] AGS GYM Leg. 264 doc. 24; AGS GYM Leg. 117 doc. 98, in Casado Soto 1988, 350-353; also in Navarrete 1971, 22.1, doc. 76, fols. 321v-323v.
[61] AGS GYM Leg. 264 doc. 24; AGS GYM Leg. 245 doc. 11.

provided for the maximum breadth. The committee of shipwrights proposed a length of 59 cubits (33.93 m) for the galleons, also without specifying the height (Table 10) (Figure 16).[62]

Barros also suggested two different lengths for the group of large galleons, 70 cubits (40.25 m) for warships and 61.5 (35.36 m) for merchant vessels. On the other hand, the committee of shipwrights specified a length of 64 cubits (36.8 m) for both warship and merchant galleons, 2.5 cubits (1.44 m) longer than what Barros recommended for merchant vessels, and six cubits (3.45 m) shorter than the lengths of Barros's warships. Neither Barros nor the committee mentioned any height for the ships' lengths but it may be assumed that the lengths were measured at the same level as the ships' maximum breadth. In Barros's designs the maximum breadth was situated at the same level as the location of the main deck (*segunda cubierta*), while in the committee's report it was placed one cubit (0.575 m) above the main deck (*segunda cubierta*) (Table 10) (Figure 17).[63]

*Depth of hold (***puntal***) and deck configuration*

The design reports also included the galleons' depth of hold (*puntal*), measured from the ceiling planking (*soler*/*granel*) of the master frame to the upper surface of the main deck (*cubierta principal/segunda cubierta*), and to the level of the ship's maximum

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[62] AGS GYM Leg. 264 doc. 24; AGS GYM Leg. 245 doc. 11.
[63] AGS GYM Leg. 264 doc. 24; AGS GYM Leg. 245 doc. 11.

breadth.[64] The Spanish term *puntal* (depth of hold), however, can also designate either the space or vertical distance between two decks.[65]

The examination of the three design reports for the Twelve Apostles reveals that the galleons were conceived as three-deckers independently of their tonnage. However, the way in which information about the deck configurations is provided can be misleading and sometimes incomplete. For instance, the row of unplanked beams (*baos vacíos*) are not mentioned in the first proposal that the committee sent to the king, nor was the orlop deck (*primera cubierta*) of the small galleons.[66] Barros, on the other hand, described the deck configuration of the galleons only up to the main deck (*segunda cubierta*), while for the remaining decks he simply indicated that they should follow the model of Guarnizo galleons.[67] The final proposal of committee did, however, include the complete deck configurations for all the galleons except for the height of the upper deck for the small galleons.[68] Nevertheless, the combination of the information provided in the three design reports of the Twelve Apostles and Barros's previous galleons permits one to determine the deck configuration for all the new galleons.

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[64] AGS GYM Leg. 264 doc. 18; AGS GYM Leg. 264 doc. 24; AGS GYM Leg. 245 doc. 11; This *puntal* (depth of hold) corresponded to the surveying measurement used in calculating the tonnages of the vessels. It also determined the height at which the ship's length and breadth were measured, see BMN Sección de manuscritos n. 1816 fols. 121-3, cited in Casado Soto 1988, 289-91. However, these were also the same dimensions used to design the vessels; conversely, Escalante (1985, 39-40) indicates that the real *puntal* (depth of hold) of a vessel is the vertical distance measured from main deck to the masters floor (*plan*) at on top of the keel. The ship's length and breadth were also measured at the level of the main deck. Escalante 1985, 39-40. In this case, Escalante is referring to the construction measurements defined by O'Scanlan (1831, 442).

[65] O'Scanlan 1831, 442.

[66] AGS GYM Leg. 264 doc. 18.

[67] AGS GYM Leg. 264 doc. 24.

[68] AGS GYM Leg. 245 doc. 11.

In the first proposal of the committee, the depth of hold at the main deck (*cubierta principal*) of the small galleons was 10 cubits (5.75 m) while the grating deck (*jareta*), which became the ship's upper deck (*puente*), was situated 3.75 cubits (2.16 m) above the main deck (Table 10) (Figure 21).[69] Barros proposed a different deck configuration with depth of hold of 11 cubits (6.33 m) for the main deck (*segunda cubierta*). Barros also noted that the committee's proposal did not mention the location of the row of unplanked beams (*baos*) and lower deck (*primera cubierta*), which it made it seem as if the hull was hollow up to the level of the main deck (*segunda cubierta*). Therefore, he proposed a row of unplanked beams situated four cubits (2.3 m) above the ceiling planking, with the lower deck (*primera cubierta*) at a height of 7.25 cubits (4.17 m), and the main deck (*segunda cubierta*) at 11 cubits (6.33 m). According to Barros, this deck configuration was identical to those of the galleon *San Cristóbal* and the *Capitana* (Admiral) of the Andalusian squadron, and the unplanked beams were intended to strengthen the lower part of the hull up to the main deck (*segunda cubierta*), where the heavy ordnance was located. The configuration of the upper deck (*puente*) with the grating (*jareta*) and upper works was the same as in the galleons he built in Guarnizo, with the upper deck situated 3.75 cubits (2.16 m) above the main deck **(**Table 10**)** (Figures 15 and 21).[70]

The final design report of the committee provided a detailed deck configuration for the small galleons, which also differed from Barros's proposal. According to this

[69] AGS GYM Leg. 264 doc. 18.
[70] AGS GYM Leg. 264 doc. 24; AGS GYM Leg. 245 doc. 11.

report, the row of unplanked beams (*primeros baos*) was at a height of around four cubits (2.3 m), the orlop deck (*primera cubierta*) at 6.5 cubits (3.74 m), and the main deck or gundeck (*segunda cubierta de la artilleria*) at 9.5 cubits (5.46 m). The committee of shipwrights responded to Barros's arguments saying that with this deck configuration, the small galleons would have a shallower draught than the galleon *San Cristóbal*, something that was very convenient for naval warfare. This report did not mention the location of the upper deck (*jareta/puente*) although it clearly stated that the maximum breadth (*manga/lo más ancho*) should be "*at 10 ½ cubits, one cubit above the main deck (*segunda cubierta*), between both decks*." Therefore, if this design followed the configuration of the galleons built earlier in Guarnizo, it must be assumed that the upper deck (*jareta/puente*) was situated 3.75 cubits above the main deck (*cubierta principal/segunda cubierta*) (Table 10) (Figure 21).[71]

The initial design of the medium-size galleons did not mention the row of unplanked beams (*baos*) although it indicated that the height of the orlop deck (*primera cubierta*) was 9 cubits (5.18 m). The main deck (*segunda cubierta*) was at 3.5 cubits (2.01 m) above the orlop deck, and the grating deck (*jareta*), which again became the upper deck (*puente*), 3.75 cubits (2.16 m) above the main deck. The configuration of the upper works had to follow the model of the galleons that Barros had built in Guarnizo (Table 10**)** (Figure 22).[72] Barros's proposal only indicated that the row of unplanked beams (*baos*) were situated at a height of 4.5 or 5 cubits (2.59 and 2.88 m), with the

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[71] AGS GYM Leg. 245 doc. 11.
[72] AGS GYM Leg. 264 doc. 18.

main deck (*segunda cubierta o puente*) at 12.5 cubits (7.19 m). The upper deck and upper works had to follow the configuration of the previous series of galleons built by Barros (Table 11) (Figures 16 and 22).[73] The committee's final design placed the row of unplanked beams (*baos*) at a height of around 4 cubits (2.3 m), depending on the length of the scarfs between the first and second futtocks (*genoles*). The height of the orlop deck (*primera cubierta*) was 8 cubits (4.6 m), with the main deck (*segunda cubierta*) at 11.5 cubits (6.61 m), and the grating/upper deck (*jareta/puente*) at a total height of 15 cubits (8.63 m) (Table 10) (Figure 16 and 22).[74]

With respect to the design for the large galleons, the first report of the committee provided the height for all three decks of the galleons although it did not mention the row of unplanked beams (*baos*). According to the report, the orlop deck (*primera cubierta*) was located at a height of 10 cubits (5.75 m), the main deck (*segunda cubierta*) was situated 3.5 cubits (2.01 m) higher, and the grating/upper deck (*jareta/puente*) 3.75 cubits (2.16 m) above the main deck (Table 10) (Figure 17).[75] In contrast, Barros recommended to set the row of unplanked beams (*baos*) at a height between 5 and 5.5 cubits (3.16 m), depending on the scarfs of the first and second futtocks, and the main deck (*segunda cubierta*) at a height of 13.5 cubits (7.76 m). As in the other reports, the remaining specifications of the galleons was to follow the model of the galleons built in Guarnizo (Table 10) (Figures 17 and 23).[76] The final design of the committee for the

[73] AGS GYM Leg. 264 doc. 24; AGS GYM Leg. 245 doc. 11.
[74] AGS GYM Leg. 245 doc. 11.
[75] AGS GYM Leg. 264 doc. 18.
[76] AGS GYM Leg. 264 doc. 24; AGS GYM Leg. 245 doc. 11.

large galleons indicated that the height of the row of unplanked beams (*baos*) depended on the scarfs (*escarpes*) between the floors and first futtock, as in Barros's proposal, although no figure was provided. The orlop deck (*primera cubierta*) was to be placed at a height of 9 cubits (5.18 m) while the main deck (*segunda cubierta*) should be at 12.5 cubits (7.19 m), and the upper deck (*jareta*) at 16 cubits (9.2 m) (Table 10) (Figures 17 and 23). The shipwrights of the committee believed that the large galleons would have a draft shallower than 11 cubits (6.33 m) if they were built according to these dimensions due to the proportion between the ship's maximum breadth and floor. Unfortunately, none of the reports mention the dimensions of the ship's main floor. This shallow draft would allow the galleons to sail safely across the Sanlúcar sandbar even during low tide when the maximum depth was only 12 cubits (6.9 m). In fact, the large galleons would have a shallower draft than the galleons that Barros had built in Guarnizo, whose draft was deeper because of their narrow waterline breadth.[77]

Barros, however, thought that the excess tonnage of the large galleons would contribute to an increase in their draft, preventing them from crossing the Sanlúcar sandbar or even entering the harbors of the Indies. Moreover, the hulls of the galleons would suffer structural issues if their main floor timber was increased to reduce the ship's draft. To remedy this situation, Barros recommended building the four large galleons according to the dimensions of the galleass *San Cristóbal,* which he built in Deusto in 1578. The *San Cristóbal* had a keel length of 42 cubits (24.15 m), 38 cubits

[77] AGS GYM Leg. 245 doc. 11.

(21.85 m) of clean keel with a 4-cubit (2.3 m) gripe, a total length between perpendiculars of 63 cubits (36.23 m) at a height of 11 cubits (6.33 m), and a breadth of 19 cubits (10.93 m). The row of unplanked beams were situated at a height of five cubits (2.88 m), with the maximum breadth and main deck (*segunda cubierta*) at 12.5 cubits (7.19 m). As usual, the deck configuration, gratings, and upper works followed the design of the galleons of Guarnizo. The remaining eight galleons would be built according to the dimensions of the small ones while there would be no need to construct the medium-sized galleons. However, the shipwrights argued that the actual breadth of the galleass was only 18 cubits (10.35 m). Moreover, *San Cristóbal* required the high tide to cross the Sanlúcar sandbar due to its 13-cubit (7.48 m) draft.[78]

In his proposal, Barros indicated that the lower decks of the galleons (*primera cubierta*) were caulked and located below the waterline to ensure the buoyancy of the galleons if the integrity of the hulls were compromised during combat. Moreover, the caulking of the lower and main decks, including the filler planks (*escoperadas*), would also help to preserve the ship's provisions that were stowed in between decks. Finally, the soldiers in the ship could take shelter from gunfire in the lower deck before boarding an enemy vessel. However, the shipwrights considered this last option impractical although they thought the lower deck could serve to accommodate the wounded and the surgeon during a naval engagement.[79]

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[78] AGS GYM Leg. 264 doc. 24; AGS GYM Leg. 264 doc. 18.
[79] AGS GYM Leg. 245 doc. 11.

*The floor (*plan*)*

The floor (*plan*) corresponds to the bottom of a vessel, or horizontal distance, between the turn of the bilges.[80] This dimension, together with depth of hold and maximum breadth, was crucial for the design of the master frame and the ship's draft. Spanish vessels needed shallow drafts to be able to cross the Sanlúcar sandbar and to enter the harbors of the Indies. However, despite the importance of the main floor length for ship design, neither the committee of shipwrights nor Barros mentioned it in their respective reports. The only document in which this dimension appears is a letter that Hernando de la Riva Herrera sent to the King regarding the construction of the galleons in Guarnizo. In this letter, Riva Herrera cited the dimension of the main floor of *San Pedro*, one of the largest galleons in the group. Riva Herrera realized, after calculating the tonnages according to the dimensions provided by Cardona, that the galleons were likely to be larger than initially planned. However, he also thought that *San Pedro* would have a shallower draft than the previous smaller galleons because of the length of its main floor, which was seven cubits (4.03 m).[81] This measurement equaled 1/3 of a ship's maximum breadth, which was the traditional ratio for ship's floor length in Spain during the 16th century.[82] Therefore, the lengths of floor for the small- and medium-sized galleons have been calculated according to this ratio (Figures 21, 22, and 23).

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80 O'Scanlan 1831, 424; Steffy 1994, 271; For the purposes of this study, the ship's floor (*plan*) and the ceiling planking (*soler*/*plan*) have been located at the same level in order to reconstruct the ships' sections and to calculate hull ratios.

81 AGS GYM Leg. 245 doc. 33.

82 Palacio 1944, 92v; Cano and Dorta 1964, 62, 83, 102.

Variations in the dimensions of the Twelve Apostles

The Twelve Apostles were finally built according to the dimensions specified in the final design report of the committee of shipwrights. Although the galleons exceeded the tonnages that the King initially requested, he accepted the explanations with which the shipwrights justified the discrepancies. Moreover, Barros did not take part in the construction of the galleons and his design was dismissed.

Once the main dimensions and tonnages of the galleons were determined, they had to be realized during the construction process. This was a complex task that depended on several factors including the available construction materials, the location of the shipyards, and the expertise of shipwrights and carpenters in charge of the construction. However, transferring the theoretical dimensions of a vessel into a physical reality was a difficult process, as observed by Escalante in 1575. According to him, it was not uncommon that the tonnage of a vessel became larger than initially expected after their construction.[83] This occurred because the vessels were built by eye instead of following a set of construction plans. In an attempt to remedy this problem, captain Juan de Veas, master shipwright for the King, proposed in the early 17th century a set of rules and proportions for oceangoing galleons that were included in the new *Ordenanzas* (shipbuilding regulations) issued in 1613. Veas claimed that if vessels were built following his rules, they would all become identical to their original design dimensions as if they were built using the same mould. His proposals, however, were severely

[83] Escalante 1985, 38.

criticized by the officials of the House of Trade in Seville who argued that ships should be built by eye.[84] Despite the fact that new sets of *Ordenanzas* (shipbuilding regulations) were issued and modified during the 17th century, the problem lasted at least until the 18th century, when Antonio de Clariana y Gualbes admitted that it was extremely difficult to build a ship in a perfect manner. He thought that there were no two identical ships even if the same exact dimensions and rules were used in their construction.[85]

Cristóbal de Barros noted other factors in the late 16th century that also contributed to variations of the original design dimensions of a ship after its construction. According to Barros, these variations also depended on the weight of the wood used for the construction of the ship, and the firmness of the ground in the shipyard. Even if the theoretical dimensions of a ship were applied correctly during construction, the ship usually turned at about 20 tons of burden (*toneles*) larger or smaller, but normally larger, than its designed tonnage. This occurred due to the weight of the wood used for the construction of the frames. The heavy futtocks sank in the soft ground of the shipyard, as did the wooden shoring posts that supported the sides of the frames before the frames could be secured with deck beams and, therefore, the original breadth of the ship under construction was increased inadvertently. This accidental variation in the ship's breadth, in turn, brought with it an increase in the final tonnage of the vessel of up to 30 tons of burden (*toneles*).[86] The problem was so common that the

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[84] Fernández Duro 1880, 5:60.
[85] Artíñano y de Galdácano 1920, 49, also in Casado Soto 1988, 74.
[86] Navarrete 1971, 22.1., doc. 76, fol. 325; also in Casado Soto 1988, 149.

new *Ordenanzas* (shipbuilding ordinances) of 1618 regulated the maximum breadth increment allowed during the construction of a ship as not exceeding 0.5 cubit (0.29 m) of the design maximum breadth.[87]

The survey of the Apostles *San Matías*, *San Bartolomé*, and *San Tadeo* conducted in Portugalete in 1592 showed these variations between the galleons' original design values and their final dimensions. The surveyed dimensions of the ships included the maximum breadth (*manga*), depth of hold (*puntal*), and hull length (*esloria*) rather than the keel length as this value was not used in calculating the ship's volume. The survey report provided the depth of hold (*puntal*) of the vessels, which were measured from the ceiling planking (*granel*) to the gundeck (*cubierta de la artillería*) but also to the height of the ship's maximum breadth or width (*manga*/lo *más ancho de la manga*). It should be noted that the hull length (*esloria*) was measured at the level of the ship's maximum breadth and not at the main or gundeck. In addition, the survey also measured the vertical distance between the upper side of the keel and the surface of the ceiling planking of the main frame. Therefore, it is possible to calculate the galleons' construction depth of hold (*puntal de construcción*) by combining the vertical measurements provided. Finally, the report clearly stated that the galleons had three decks and rounded sides without variations in the curvature.[88]

The survey of *San Tadeo* revealed similar dimensions to those indicated in the committee's design proposal for the medium-sized galleons. The major differences

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[87] See *Ordenanzas* of 1618, *Sección* 18 in Boix 1841, 4:25.
[88] AGS GYM Leg. 358 doc. 188.

observed between the design and the final dimensions were in relation to the hull length and breadth of the galleon, which were 1.33 cubits (0.76 m) shorter and 1.25 cubits (0.72 m) wider than initially planned. It should be noted here that the increase in breadth increment would have exceeded the maximum allowance indicated in the *Ordenanzas* of 1618. The depth of hold measured at the level of the main deck was one cubit (0.575 m) lower than in the original design, while the height to the ship's maximum breadth was also 0.5 cubits (0.29 m) lower (Table 10). In addition, the document also indicated that the vertical distance between the upper surface of the keel and the ceiling planking was 0.5 cubits (0.29 m). This measurement included the thickness of the ceiling planking and the main floor timber.[89]

The dimensions of *San Matías* were closer to those of the large galleons than to any other group size although, in this case, the survey showed a length 2.75 cubits (1.58 m) longer than in the design report. The ship's maximum breadth was only 0.83 cubits (0.48 m) wider than the design dimension and situated 0.5 cubit (0.29 m) lower than in the design report. On the other hand, the depth of hold at the height of the gundeck, or main deck, measured from the ceiling planking, was the same as in the design report. In fact, *San Matías* was the galleon whose dimensions presented the least differences with the design values except for its hull length (Table 10). In the case of the *San Matías*, the distance between the top of ceiling planking and the keel was 0.66 cubits (0.38 m).[90]

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[89] AGS GYM Leg. 358 doc. 188.
[90] AGS GYM Leg. 358 doc. 188.

Finally, *San Bartolomé* presented a set of dimensions ranging between the large and medium-sized galleons. The ship's hull length and maximum breadth were only 0.75 and 0.5 cubits (0.43 and 0.29 m) shorter than the dimensions proposed for the large galleons, whereas the height of the galleon's gundeck and the level of its maximum breadth were both located one cubit (0.575 m) lower than in the original design. These dimensions placed *San Bartolomé* within the group of the large galleons although the height of the ship's maximum breadth was identical to the design value proposed for the medium-sized galleons. However, both the hull length and maximum breadth exceeded the original dimensions for the medium-sized galleons by 4.25 and 1.5 cubits (2.44 and 0.86 m). Therefore, it is reasonable to think that these vessels belonged to the category of the large galleons (Table 10). The vertical distance between the top of the keel and the ceiling planking was 0.5 cubits (0.29 m).[91]

In any case, the variations observed in the final dimensions of the galleons after their construction were a common problem in shipbuilding from the 16th to the early 18th century. These discrepancies were due to the difficulties in transferring the original design specifications to the actual ship under construction. The final dimensions and shape of a vessel depended on the expertise of the shipwrights and carpenters in charge of the construction since tradition and craftsmanship played a decisive role in this process. Although ships were the most advance machines of their time, they were built within the context of a pre-industrial society with limited technological resources.

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[91] AGS GYM Leg. 358 doc. 188.

Technological factors such as tools and means of production did not always allow an accurate fulfillment of the original design.

CHAPTER IV

THE TWELVE APOSTLES: HULL RATIOS AND SHIP FUNCTION IN SPAIN (1550-1698)

When Philip II ordered the construction of the Twelve Apostles, he clearly specified that the galleons had to be specifically designed and built as warships. However, during the design process Cristobal de Barros warned Philip II that the dimensions and proportions included in the proposal of the Santander committee corresponded to those of merchant vessels.[1] Warships were usually designed as stronger, sleeker, and lower vessels favoring speed and maneuverability, although this design also reduced their cargo capacity. In turn, merchant ships had for deeper holds and wider breadths to maximize cargo capacity and stability. According to Cano, however, traditional 16th-century ship design in Spain, Italy, and other nations was regulated by the *as-dos-tres* rule (1:2:3). This rule determined that for each unit of breadth, there were two units of keel and three of length, while the depth of hold equaled 3/4 of the breadth.[2] Moreover, it should be noted that Spanish galleons have been traditionally defined as multipurpose vessels because they served both military and commercial purposes depending on the circumstances.[3] In order to determine if the Twelve Apostles were designed as warships, merchantmen or multipurpose vessels, it is necessary to compare

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[1] AGS GYM Leg. 264 doc. 24.
[2] Cano and Dorta 1964, 62; It should be noted that such a high depth of hold-to-breadth ratio could be the result of measuring the depth of hold up to the upper deck, as was done traditionally by Portuguese, Andalusian, and Biscayan shipbuilders, see also Cano and Dorta 1964, 92
[3] Artíñano y de Galdácano 1920, 98; Phillips 1994, 103.

their hull ratios with previous and later series of galleons, 16th- and 17th-century naval and merchant vessels, as well as with contemporary shipbuilding treatises and manuscripts. This comparative analysis aims to verify the relationship between ship design and function, as well as to understand the changes in hull ratios used in Spanish naval design from the second half of the 16th century until the late 17th century

The main dimensions used in this analysis to calculate the hull ratios are the ship's length, breadth, and depth of hold as they appear in contemporary shipbuilding contracts, treatises, manuscripts, ordinances, ship surveys, as well as archaeological remains. The ship's length corresponds to the length between the stem and the sternpost measured at the level of the main deck or the height at which is located the ship's maximum breadth or width.[4] The ship's breadth corresponds to its maximum width measured horizontally at the master frame, excluding the thickness of hull planking.[5] Finally, the depth of hold used in this study corresponds to the vertical height measured at the master frame from the ship's ceiling planking (*soler*), floor (*plan*) or the top of the keel (*ras de la quilla*), depending on the specification, to the level of the ship's breadth

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[4]; O'Scanlan 1831, 258; Palacio 1944, 92; According to Escalante (1985, 39-40) the ship's length (*esloria*) was the distance between the sternpost to the stem of the vessel along the main deck, where the ship's breadth and depth of hold were also measured; BMN Sección de manuscritos n. 1816 fols. 121-23, in Casado Soto 1988, 289-91; Steffy 1994, 253.

[5] O'Scanlan 1831, 352; BNM Sección de manuscritos n. 1816 fols. 121-23, in Casado Soto 1988, 289; AGS GYM Leg. 117 doc. 98, in Casado Soto 1988,, 351; also in Navarrete 1971, 22.1, doc. 76. fol. 322; This dimension also refers to the molded breadth defined by Steffy (1994, 254); Escalante (1985, 39) defines the ship's breadth as the width of the vessel measured at the level of the main deck or the deck immediately below the upper deck.

or maximum width, which is not always situated at the level of the main deck. In any case, the depth of hold does not include the deadrise of the main floor.[6]

Hull ratios and ship function in Spain, Portugal, and the Mediterranean (1550-1698)

In order to calculate hull ratios of the vessels designed and built in Spain during the 16th and 17th centuries, it is necessary to know their primary dimensions, such their length, breadth, and depth of hold. There are several sources that provide a ship's main dimensions, such as design reports, shipbuilding contracts, treatises, manuscripts, ordinances, ships surveys, and also archaeological evidence.

During the second half of the 16th century, several vessels were designed and built specifically as warships in the shipyards of northern Spain. One of the first examples in Spain of ships specifically designed as oceangoing warships were the galleons and galleasses (*galeazas*) that Alvaro de Bazán the Elder (*el Viejo*) built in 1540 and 1550 for coastal defense of the Iberian Peninsula, and to escort the fleets of the Indies run.[7] Unfortunately, apart from their tonnages and a few construction characteristics, their dimensions are not known, which makes it impossible to calculate their hull ratios. Fortunately, the dimensions of later series of galleons built in Spain

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[6] O'Scanlan 1831, 442; BMN Sección de manuscritos n. 1816 fols. 121-123, cited in Casado Soto1988, 289-91; Escalante (1985, 39-40) also indicates that the real *puntal* (depth of hold) of a vessel is the vertical distance measured from main deck to the floor (*plan*) at the level of the top of the keel. The ship's length and breadth were also measured at the level of the main deck. It is likely, however, that Escalante was referring to the construction measurements.

[7] Fernández Duro, 1880 5:14-8; see also Phillips 1994, 104; Casado Soto 2003, 43-4.

during the 16th century are well documented in several design reports and ship surveys. In addition, the main dimensions of other series of galleons built in the shipyards of the central Mediterranean, such as those of Naples and Ragusa (Dubrovnik), which in the 16th-century served in Spanish Armadas, have also been included in this study.

Paralleling the design and construction of the different series of galleons in Spain during the second half of the 16th century, there was the production of several shipbuilding manuscripts and treatises in Spain, Portugal, and Italy. The authors of these works intended to define the ideal dimensions and technical characteristic of any ship depending on its function as warship, merchant vessel or multipurpose ship. Additionally, during the 17th century, different sets of shipbuilding ordinances were issued in Spain to regulate and standardize ship design in general.

In addition to the different sets of shipbuilding ordinances and manuscripts written during the 17th century, there are also several published shipbuilding contracts and ship surveys that specify actual ship dimensions. It is possible, therefore, to compare the dimensions and hull ratios of these galleons with the theoretical ratios provided in the shipbuilding treatises and manuscripts to determine the accuracy and influence of theoretical projections in naval design.

On the other hand, it is almost impossible to calculate accurately the hull ratios of the majority of the 16th- and 17th-century Spanish shipwrecks that have been archaeologically excavated due to the fragmentary condition of their hull remains. Frequently, however, the primary archaeological evidence available includes fragments of a ship's keel and end posts, as well as its floors and futtocks. Therefore, the hull ratios for these vessels are determined indirectly based on the dimensions of partial hull remains, such as estimated keel length, and application of the proportions provided in contemporary shipbuilding treatises and manuscripts.[8] However, there are exceptions to this, such as with the hull remains of the 24M wreck excavated in Red Bay, Canada, whose hull ratios have been accurately calculated based on measurements taken directly from its well-preserved hull remains.[9]

Comparative analyses of the hull ratios provided by these different sources allow the examination of the evolution of Spanish shipbuilding design from the second half of the 16th to the late 17th century, in order to determine the changes in the relation between the design and function of vessels based on their main ratios.

Instructione sul modo di fabricare galere *(ca. 1550)*

By the mid-16th century, the shipwright Pre Teodoro di Niccolò had already proposed in Venice different hull proportions for ships depending on their naval or merchant function. Based on the dimensions that Pre Teodoro provided in his shipbuilding manuscript, a merchantman or *nave* should have a length-to-breadth ratio of 3.1:1 and a depth of hold-to-breadth of 0.5:1. On the other hand, he recommended

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[8] *San Esteban*, Doran and Doran 1978, 375-84; Highborn Cay wreck, Oertling 1989b, 252; Emanuel Point I, Smith et al. 1995, 64-5; Pepper wreck, Castro 2003, 16; *San Diego*, L'Hour 1996, 149-53; Studland Bay Wreck, Thomsen 2000, 80-1; Western Ledge Reef, Bojakowski 2012, 295-333; Cattewater, Redknap 1984, 136-9.

[9] Loewen 2007, 3:91.

longer, narrower, and lower hull proportions for a galleon designed as a warship, with a length-to-breadth ratio of 3.6:1 and depth of hold-to-breadth ratio of 0.45:1 (Table 12).[10]

Table 12. Ships' dimensions and ratios 1550-1571.

SOURCE	YEAR	Length Cubits	Breadth Cubits	Main deck (DOH) Cubits	Maximum breadth (height) Cubits	L/B	DOH/B
Pre Teodoro (Merchantman)	ca. 1550	-	-	-	-	3.1:1	0.5:1
Pre Teodoro (Warship)	ca. 1550	-	-	-	-	3.6:1	0.45:1
24M vessel, Red Bay (Labrador, Canada)	1565	37	13.16	7.9	7	2.81:1	0.53:1
Menéndez's galleons (Barros 1581)	1567	44	12-13	7.5	7.5	3.52:1	0.60:1
Menéndez's galleons (1567) *San Mateo* (1571)	1571	42.16	11.86	7.76	7.76	3.55:1	0.65:1
Menéndez's galleons *San Bartolomé* (1571)	1571	41.67	11.86	8.4	8.4	3.51:1	0.71:1

The 24M vessel at Red Bay (1565)

The 24M ship has been tentatively identified as the Basque galleon or *nao* whaler *San Juan* from Pasajes (Guipúzcoa, Spain), which sank in Red Bay Harbor, Labrador (Canada) in 1565, although this identification has not yet been confirmed.[11] The hull of the Red Bay ship was found collapsed outwards onto the seabed, although it still formed a coherent structure up to the level of the waterline. In addition, scattered and broken hull timbers allowed for the reconstruction of the hull up to the waterline with "a high

[10] Lane 1992, 235; *Nave* definition according to Lane (1934, 46).
[11] Bernier and Grenier 2007, 4:291-2, 307.

level of confidence."[12] Therefore, it was possible to determine the main dimensions of the hull from the archaeological remains for use in calculating its main ratios. According to the ship's main dimensions, it had a length-to-breadth ratio of 2.81:1, and a depth of hold-to-breadth ratio of 0.53:1 (Table 12).[13]

The **galeoncetes** *of Pedro Menéndez de Avilés (1568)*

The next series of oceangoing warships built for the Spanish Crown, after Bazán's galleasses and galleons, were the 12 small galleons or *galeoncetes* that the *Adelantado de la Florida*, Pedro Menéndez de Avilés, constructed in Biscay between 1567 and 1569.[14] Based on the dimensions provided by the shipwrights who built them, and the ships' officers who sailed them, these ships had a length-to-breadth ratio of 3.52:1, and a depth of hold-to-breadth ratio of 0.60:1.[15] In addition, the survey conducted in 1571 of two of the *galeoncetes*, *San Bartolomé* and *San Mateo*, also showed similar length-to-breadth ratios of 3.51:1 and 3.55:1, although their depth of hold-to-breadth ratios increased to 0.71:1 and 0.65:1 (Table 12).[16]

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[12] Loewen 2007, 3:2.
[13] Loewen 2007, 3:50.
[14] Fernández Duro 1880, 5:280 and Menéndez de Avilés et al. 1893, 2:390-1; also in Casado Soto 1988, 136-38.
[15] The shipwrights were Pedro de Busturria, the Elder, and Pedro de Busturria the Younger, while the ships' officers were Sancho de Valecilla, shipmaster of the *Capitana*, Miguel de Miravalles, boatswain of the galleons *San Andrés*, *San Mateo*, and *San Simón*. AGS GYM Leg. 111 doc. 166, in Casado Soto 1988, 307; also in Navarrete 1971, 22.1, doc. 76, fols. 293-293v.
[16] AGI *Contaduría* Leg. 2933. S. fol. Sevilla, 16 Noviembre 1571, cited in Casado Soto 2003, 46.

Itinerario de Navegación de los mares y tierras occidentales *(1575)*

In Spain, Juan Escalante de Mendoza also provided in his unpublished *Itinerario de navegacion de los mares y tierras occidentales* an incomplete set of ideal dimensions for the ships of the Indies run. In his work, Escalante clearly advocated for the construction of multipurpose vessels without distinction between warships and merchant vessels, with a length-to-breadth ratio of 3.18:1 (Table 13).[17]

Table 13. Ships' dimensions and ratios 1575-1580

SOURCE	**YEAR**	**Length** Cubits	**Breadth** Cubits	**Main deck (DOH)** Cubits	**Maximum breadth (height)** Cubits	**L/B**	**DOH/B**
Escalante	1575	7	2.2	-	-	3.18:1	-
Galleass *San Cristobal*	1578	63	19	12.5	12.5	3.32:1	0.66:1
Oliveira (actual breadth)	1580	150	51.3	24	24	2.92:1	0.47:1
Oliveira (treatise breadth)	1580	150	48	25	24	3.13:1	0.75:1

Barros's galleasses (1578)

In 1578, Cristóbal de Barros built in Deusto (Biscay) two galleasses to replace Menéndez's *Capitana* (Admiral) and *Almiranta* (Vice Admiral) for the fleets of the Indies run.[18] These galleasses were also conceived as oceangoing warships, and the main dimensions for one of them, *San Cristóbal*, were included in the final design proposal of the committee of shipwrights for the Twelve Apostles. According to that proposal, the

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[17] In his book, Escalante (1985, 39-42) does not provide the depth of hold for his vessel.
[18] The order to build the two "galleons" is provided in AGS GA Leg. 83 doc. 197 and 198, in Casado 2003, 49.

galleass *San Cristóbal* had a length-to-breadth ratio of 3.32:1, and a depth of hold-to-breadth of 0.66:1 (Table 13).[19]

Livro da fabrica das naus *(1580)*

The Portuguese shipwright Fernando Oliveira described the dimensions and characteristics of a 600-ton *nau* or merchant vessel in his *Livro da fabrica das naus*. According to Olivera, this type of vessel required strength, excellent sailing capability, and good cargo capacity to serve as merchantmen.[20] Reviewing the dimensions proposed by Oliveira, the breadth and depth of hold were almost equal to 1/3 of the keel's length, although the ship's breadth was only slightly greater than its height.[21] However, the official ship's breadth that Oliveira provided in his treatise was measured on the upper deck, and it did not correspond to the ship's maximum breadth. In fact, the maximum breadth was situated at 1/3 of the depth of hold below the upper deck. This point corresponded to the center of a circle which defined either side of the ship's master frame, and whose radius was equal to the distance from the center of the circle to the turn of the bilge. Thus the radius corresponded to the ship's maximum half-breadth, slightly exceeding the official ship's breadth proposed by Oliveira (Figure 24).[22] If the *nau*'s actual maximum breadth and depth of hold are used to calculate the hull ratios of

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[19] AGS GYM Leg. 264 doc. 24; AGS GYM Leg. 245 doc. 11.
[20] Oliveira 1991, 162.
[21] Oliveira 1991, 166.
[22] Oliveira 1991, 185-86.

Oliveira's *nau*, the resulting length-to-breadth ratio becomes 2.92:1 instead of 3.13:1, while the depth of hold-to-breadth ratio is 0.47:1 rather than 0.75:1 (Table 13).

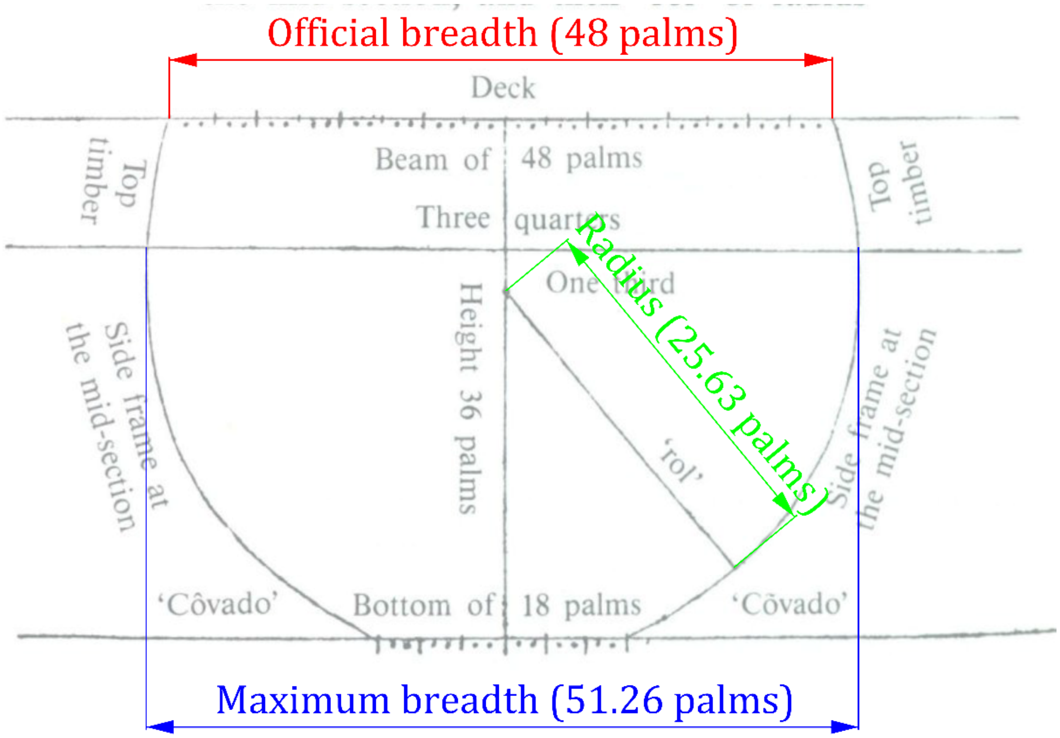

Figure 24. Oliveira's midship section for a *nao* (1580) (modified after Oliveira 1991, 187, figure not numbered).

The galleons of Cristóbal de Barros (1581)

The design of the galleons built by Barros in Guarnizo between 1582 and 1583 was initially based on the main dimensions of Menéndez's *galeoncetes* and Barros's galleasses, although these dimension were modified as the design process evolved. This series was comprised of nine galleons, with two of them (the largest ones) serving as the *Capitana* and *Almiranta* (Admiral and Vice-Admiral ships). All nine galleons were conceived as warships.[23] According to the final set of main dimensions used for the construction of these galleons, the two largest ships would have a length-to-breadth ratio of 3.5:1, and a depth of hold-to-breadth of 0.56:1. On the other hand, the smaller galleons had a length-to-breadth ratio of 3.47:1, and a depth of hold-to-breadth of 0.60:1. (Table 14).[24]

Instrucción Náutica *(1587)*

A decade after Escalante wrote his shipbuilding manuscript, Diego García de Palacio published his treatise *Instrucción náutica para el buen uso, y regimiento de las naos, su traça, y gobierno a la altura de México.* In his 1587 treatise, Palacio described the ideal dimensions and technical characteristics of a 400-ton *nao* that could serve either as a warship or merchant vessel depending on the circumstances. In fact, the only differences that Palacio indicated between the two designs were the addition of a grating above the upper deck to protect the soldiers and to serve as an upper deck, and lowering the depth of hold of the main deck by one cubit to allow more space for the soldiers and gunners between the main deck and the upper deck.[25] According to Palacio's dimensions, the *nao*

[23] Navarrete 1971, 22.1, doc. 76, fols. 286v-287, also in Casado Soto 1988, 294-95; AGS GYM Leg. 111 doc. 166, in Casado Soto 1988, 300-14; Navarrete 22.1, doc. 76, fols. 314-315v, also in Casado Soto 1988, 347-49; AGS GYM Leg. 117 doc. 98, in Casado Soto 1988, 350-53; also in Navarrete 22.1, doc. 76, fols. 315v-318.
[24] Casado Soto 1988, 193.
[25] Palacio 1944, fol. 120v-121.

had a length-to-breadth ratio of 3.21:1, and a depth of hold-to-breadth ratio of 0.47:1 (Table 14).[26]

Table 14. Ships' dimensions and ratios 1581-1587.

SOURCE	YEAR	Length (Eslora)	Breadth	Main deck (DOH)	Maximum breadth (height)	L/B	DOH/B
Small galleons Santander (September)	1581	52	15	6	9	3.47	0.6
Large galleons Santander (September)	1581	56	16	7.5	9	3.50	0.56
Palacio	1587	51.33	16	11.5	7.5	3.21	0.47

Ships of the Great Armada (1588)

The variety of ship types that comprised the Great Armada in 1588 also offers a valuable set of hull ratios that may be compared with those of the Apostles in order to examine the relationship between hull ratios and ship function. Among the vessels that took part in this naval expedition were a group of Mediterranean-built *navi* (ships) that formed the Levant squadron; Cantabrian *naos* included in the squadrons of Castile, Biscay, Guipúzcoa or Andalusia; Baltic hulks; the aforementioned galleons of Barros;

[26] Palacio (1944, fol. 90-92v) does not specify the height at which the ship's maximum breadth is located, and the illustration he provides in his treatise seems to indicate the breadth at the level of the upper deck as in the case of Oliveira's *nau*. However, the section of the master frame provided by Palacio is generated using a single circle. Therefore, if the dimensions provided by Palacio are used to reconstruct graphically the master frame of his 400-ton *nao*, the breadth and maximum width of the vessel is located at a depth of hold of 7.5 cubits, the same height at which Palacio places the *nao*'s main deck. This is the depth of hold used to calculate the depth of hold-to-breadth ratio for this analysis.

Portuguese galleons; French galleons and a Florentine galleon; and also a private Spanish galleon built for the Indies run.

The *navi* of the Levantine squadron presented an average length-to-breadth ratio of 2.87:1 with a depth of hold-to-breadth of 0.60:1.[27] It should be noted that the term *nave* was normally used to define the large round-ships designed and built as merchantmen.[28] Another major ship type that took part in the expedition of the Great Armada were the 21 Cantabrian armed *naos* (merchant vessels). The *nao* was the most common vessel built in the northern coast of Spain for trade; although not specifically designed as a warship, the *nao* could also be armed for naval warfare.[29] The average length-to-breadth ratio of the *naos* that took part in the Spanish Armada was 3.07:1 with a depth of hold-to-breadth ratio of 0.67:1 (Table 15).[30]

Portuguese, French, and Florentine galleons also took part in the Great Armada, in addition to the galleons built by Barros in Guarnizo. Nine Portuguese galleons comprised the fighting core of the Great Armada, which included the galleon *San Martín*, the Armada's flagship. Unfortunately, the main dimensions of the Portuguese galleons are not known and, therefore, their hull ratios cannot be included in this comparative analysis.[31] The length-to-breadth ratios of the French and Florentine

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[27] Casado Soto 1988, 199.
[28] Lane 1934, 46.
[29] Casado Soto 1988, 119-20.
[30] Casado Soto 1988, 199.
[31] Casado Soto (1988, 191) used the dimensions of a 500-ton galleon provided in the *Livro das Traças de Carpintaria* of Manuel Fernandes to estimate the ratios of the Portuguese galleons that took part in the Armada of 1588. Therefore, the ratios provided by Casado Soto in his book do not correspond to the actual galleons.

galleons were 3.75:1 and 3.85:1, with depth of hold-to-breadth ratios of 0.58:1 and 0.62:1 while the ratios of the private galleon were 3.25:1 and 0.62:1 (Table 15).[32]

Table 15. Armada ships' ratios 1588.

SOURCE	YEAR	Length	Breadth	Main deck (DOH)	Maximum breadth (height)	L/B	DOH/B
Mediterranean *navi* (8)	1588	-	-	-	-	2.87:1	0.60:1
Catabrian *naos* (21)	1588	-	-	-	-	3.07:1	0.67:1
Private galleon	1588	-	-	-	-	3.25:1	0.62:1
French galleon	1588	-	-	-	-	3.75:1	0.58:1
Galleon of Florence	1588	-		-	-	3.85:1	0.62:1

The Twelve Apostles (1589-1592)

The first design report for the Twelve Apostles that the committee of shipwright prepared and sent to King Philip II did not include the lengths of the vessels, making it impossible to calculate their length-to-breadth ratios.[33] On the other hand, according to this report, the keel-to-breadth ratios were almost identical for the three groups of galleons independent of their size, which ranged between 2:1 for the small galleons and 2.05:1 for the medium-sized and large ones. Basically, the length of ships' keels doubled their breadths following the traditional 16th-century proportions of "*as-dos-tres*"

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[32] Casado Soto 1988, 193.

[33] The depth of hold used in calculating these ratios corresponds to the vertical height measured at the master frame from the ceiling planking to the level of the ship's maximum breadth or width. This elevation, however, is not always located at the same height as the main deck.

(1:2:3).[34] The group of galleons with the lower hulls were the small vessels with depth of hold-to-breadth ratio of 0.62:1, while the deepest hulls corresponded to the medium-sized galleons with 0.68:1 followed by the large ones with 0.66:1. In all three cases, the depth of hold of the galleons was slightly higher than 2/3 of their breadths (Table 16).[35]

Table 16. Dimensions and ratios of the first design of the Apostles and César's proposal (1588-1589).

SOURCE	**YEAR**	**Length** Cubits	**Breadth** Cubits	**Main deck (DOH)** Cubits	**Maximum breadth (height)** Cubits	**L/B**	**DOH/B**
Small Apostles	1588	-	17	10	10-11	-	0.62:1
Medium Apostles	1588	-	18.5	12.5	11-12	-	0.68:1
Large Apostles	1588	-	20.5	13.5	12-13	-	0.61:1
Luis Cesar 500-ton galleons	1589	136	43	22.5	22.5	3.16:1	0.52:1
Luis Cesar 600-ton galleons	1589	164	46	24	24	3.57:1	0.52:1

Luis César's design

The King forwarded the first design report to Luis César, the Purveyor of the Storehouses and Armadas of the Crown of Portugal (*Provedor dos Amazéns e das Armadas da Coroa de Portugal*), for his perusal in case he could suggest any modification to improve the designs.[36] In his reply to the King, Luis César included two new sets of dimensions for 500- and 600-ton galleons designed as warships. However, César provided the dimensions of the vessels in Portuguese *rumos* and *palmos de goa*

[34] AGS GYM Leg. 264 doc. 18; Crescentio 1607, 63; Cano and Dorta, 1964, 62.
[35] AGS GYM Leg. 264 doc. 18.
[36] AGS GYM Leg. 264 doc. 17.

instead of Spanish *codos* (cubits). In his letter to the King, Luis César also noted that with those dimensions, the galleons would become slightly larger than the King ordered because the Portuguese *toneladas* (tons) were larger than the Castilian and Biscayan tons.[37] César's dimensions for the 500-ton galleons resulted in a length-to-breadth ratios of 3.16:1 with a depth of hold-to-breadth ratio of 0.52:1. The dimensions provided for the 600-ton galleons, on the other hand, did not include the rake of the stem, making it impossible to calculate its length-to-breadth ratio, although the depth of hold-to-breadth was the same as that for the other galleon (Table 16).[38]

Barros's design

Cristóbal de Barros also prepared an alternative design for the Twelve Apostles, which included a single hull length for the small galleons but two different lengths each for both the medium-sized and large Apostles, depending on if they were designed as warships or merchantmen. According to Barros, a galleon designed as warship needed a longer length with respect to its breadths, just the opposite of merchantmen. However, the dimensions that he proposed for the small galleons resulted in a length-to-breadth ratio of only 2.82:1, which was slightly lower than the traditional *as-dos-tres* (1:2:3) proportions. The length-to-breadth ratios for the medium-size and large galleons, on the

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[37] 1 *rumo* = 2 *goas* = 6 *palmos de goa* (1.540 m), *Goa* = 3 *palmos de goa* = ½ *rumo* (0.77 m), *Palmo de goa* = 1/3 *de goa* = 1/6 *rumo* (0.256 m), 1 Portuguese *tonel/tonelada* = 2 *pipas* = 1.611 cubic meters in Lavanha and Barker 1996, 108; One *codo de ribera* = 0.575 m. One *tonel macho* = 8 cubic *codos de ribera* = 1.52 cubic meters. One *codo de Castilla* = 0.558 m. One *tonelada* (Seville) = 8 cubic *codos de Castilla* = 1.38 cubic meters. One *tonelada* (freight ton) = *tonel macho* or *tonelada* plus 20% - 25%. Casado Soto 1991, 104.
[38] AGS GYM Leg. 264 doc. 19.

other hand, varied as expected depending on their function. If designed as warships, the length-to-breadth ratios were 3.35:1 and 3.41:1. However, the ratios were lowered to 3:1 if Barros's lengths for merchantmen were applied, matching perfectly the traditional 16th-century *as-dos-tres* rule. The depth of hold-to-breadth ratio of the small galleons was increased up to 0.65:1, while the ratios of the medium-sized and large galleons were identical to the first design of the committee of shipwrights with 0.68:1 and 0.66:1 (Table 17).[39]

Table 17. Barros design dimensions and ratios (1589).

BARROS'S APOSTLES January 1590	**YEAR**	**Length** Cubits	**Breadth** Cubits	**Main deck (DOH)** Cubits	**Maximum breadth (height)** Cubits	**L/B**	**DOH/B**
Small galleons	1589	48	17	11	11	2.82:1	0.65:1
Medium galleons (Warships)	1589	62	18.5	12.5	12.5	3.35:1	0.68:1
Medium galleons (Merchantmen)	1589	55.5	18.5	12.5	12.5	3.00:1	0.68:1
Large galleons (Warships)	1589	70	20.5	13.5	13.5	3.41:1	0.66:1
Large galleons (Merchantmen)	1589	61.5	20.5	13.5	13.5	3.00:1	0.66:1

The final design of the committee of shipwrights

The King forwarded Barros's report to the committee of shipwrights to be revised in case the committee had to introduce changes in the original dimensions

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39 AGS GYM Leg. 264 doc. 24.

proposed for the Apostles. The committee then prepared a new report in which all of Barros's suggestions were evaluated and discussed. The final design of the shipwrights' committee for the small galleons produced a length-to-breadth ratio of 3.18:1. The committee also maintained the original depth of hold-to-breadth ratio of 0.62:1. The medium-sized and large galleons design modifications, on the other hand, resulted in length-to-breadth ratios of 3.19:1 and 3.12:1, but kept the same depth-to-breadth ratios of 0.68:1 and 0.66:1 as in the original design report (Table 18).[40]

Table 18. Second design of the committee and Portugalete's survey dimensions and ratios (1589-1592).

SOURCE	YEAR	Length Cubits	Breadth Cubits	Main deck (DOH) Cubits	Maximum breadth (height) Cubits	L/B	DOH/B
Small galleons	1589	54	17	9.5	10.5	3.18:1	0.62:1
Medium galleons	1589	59	18.5	11.5	12.5	3.19:1	0.68:1
Large galleons	1590	64	20.5	12.5	13.5	3.12:1	0.66:1
San Tadeo	1592	57 2/3	19 3/4	10.5	12	2.92:1	0.61:1
San Matías	1592	66 3/4	21 1/3	12.5	13	3.13:1	0.61:1
San Bartolomé	1592	63 1/4	20	11 1/12	12.5	3.16:1	0.63:1

The hull ratios of the Apostles San Mateo*,* San Tadeo*, and* San Bartolomé *(1592)*

Finally, there were also variations between the ratios that resulted from the final design proposal for the Apostles and the actual ratios of the galleons after their construction, as the survey of the Apostles *San Mateo*, *San Tadeo*, and *San Bartolomé*

[40] AGS GYM Leg. 265 doc. 11.

revealed in 1592. For instance, *San Tadeo*'s length-to-breadth ratio of 2.92:1 fell well below the theoretical ratio of the committee's final design report for the medium-sized galleons, with a depth of hold-to-breadth ratio of 0.61:1. In contrast, the length-to-breadth ratios of the *San Matías* and *San Bartolomé* were almost identical to the design report for the large galleons at 3.13:1 and 3.16:1 respectively, with depth of hold-to-breadth ratios of 0.61:1 for the *San Matías* and *San Tadeo*, and 0.63:1 for the *San Bartolomé* (Table 18).[41]

The Illyrian squadron (1595)

In early 1590, while the Twelve Apostles were being built, the King signed an *asiento* (contract) with two Ragusan noblemen - Pedro de Ivella, and his nephew, Estefano de Oliste - for the construction and outfitting of twelve more galleons to serve in the permanent Spanish Atlantic fleet, the Armada of the Ocean Sea (*Armada del Mar Oceáno*).[42] These twelve new galleons were built in the shipyards of the kingdom of Naples (Italy) and Ragusa (Dubrovnik, Croatia), and became known as the Illyrian squadron. The largest and strongest vessel of the squadron was *Santiago de Galicia*. Although the ships were completed in 1593, the King did not request their service until 1594, and, when the squadron finally arrived in Lisbon in 1595, seven of the original

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[41] AGS GYM Leg. 358 doc. 188. The depth of hold provided in the survey document is measured from the ceiling planking to the main deck and the level at which the ships' maximum breadth is located, above the main deck. In addition to this measurement, the document also included the vertical distance from the surface of the ceiling planking to the top of the keel which ranged between 0.66 and 0.5 cubits, depending on the galleon. The ratios used for this analysis are calculated using the depth of hold measured from the ceiling planking to the level of the ships' maximum breadth.

[42] AGS GYM Leg. 299 doc. 137; AGS GYM Leg. 299 doc. 166; see also Fonseca 2006, 23, 38, 59-60.

vessels had been replaced.[43] Their design followed the quintessence of English, Biscayan, and Ragusan galleon measurements, and, therefore, the ships were expected to be strong and maneuverable vessels, particularly when sailing close to the wind.[44] However, the analysis of the hull ratios based on the measurements of the Illyrian galleons that arrived at Lisbon in 1595 show an average length-to-breadth ratio of 2.88:1, and a depth of hold-to-breadth of 0.64:1 (Table 19).[45]

Table 19. Dimensions and ratios of the Illyrian squadron (1595).

ILLYRIAN SQUADRON	**YEAR**	**Length** Cubits	**Breadth** Cubits	**Main deck (DOH)** Cubits	**Maximum breadth (height)** Cubits	**L/B**	**DOH/B**
San Mateo y San Francisco	1595	52.75	19.42	12.8	12.8	2.72:1	0.66:1
Santa Maria La Anunciada	1595	52.08	19.14	12.17	12.17	2.72:1	0.64:1
Maria de la Misericordia	1595	55.67	20.38	12.33	12.33	2.73:1	0.61:1
Santa Maria de Tremidi	1595	48	17.13	10	10	2.80:1	0.58:1
Santa Cruz	1595	51.75	18.38	11.67	11.67	2.82:1	0.63:1
San Miguel Arcangel	1595	52.67	18.67	10.75	10.75	2.82:1	0.58:1
San Andres de Baldi	1595	54	18.67	11.33	11.33	2.89:1	0.61:1
San Juan Bautista	1595	53.5	18.47	11.2	11.2	2.90:1	0.61:1
San Andres de Caramonda	1595	52	17.88	11.86	11.86	2.91:1	0.66:1
Santiago de Galicia (Almiranta)	1595	59.67	20.5	13.25	13.25	2.91:1	0.65:1
San Geronimo de Ivella (Capitana)	1595	58.5	19	13.33	13.33	3.08:1	0.70:1
Santísima Trinidad	1595	47.5	14.67	10.83	10.83	3.24:1	0.74:1

[43] Casabán 2017, 8.
[44] AGS GYM Leg. 379 doc. 243; AGS GYM Leg. 380 doc. 107.
[45] AGS, GYM Leg. 513 doc. 204; see also Fonseca 2006, 140.

San Juan Evangelista *(1599)*

The galleon *San Juan Evangelista* was built after the Twelve Apostles, in the last years of the 16th century. This galleon belonged to a series of six galleons built specifically as warships by Antonio de Urquiola in the shipyard of Lezo (Guipuzcoa), following the King's orders.[46] Its breadth was similar to those of the medium-sized Apostles, with a length-to-breadth ratio of only 2.89:1, while the depth of hold-to-breadth ratio was 0.58:1 (Table 20).

Table 20. *San Juan Evangelista*, Crescentio and Sagri dimensions ratios (1599-1607).

SOURCE	YEAR	Length Cubits	Breadth Cubits	Main deck (DOH) Cubits	Maximum breadth (height) Cubits	L/B	DOH/B
San Juan Evangelista	1599	55.5	19 1/5	11 1/8	11 1/8	2.89:1	0.58:1
Sagri	1607	90.00	30	15	15	3.00:1	0.50:1
Crescentio	1607	90-93	30-32	15.5	15.5	3-2.90:1	0.51-0.48:1

Nautica Mediterranea *(1607)*

In 1607, Bartolomeo Crescentio published his *Nautica Mediterranea* in which he described the design and main dimensions for a galleon, or *nave*, to be used as either a merchant vessel or a warship. Crescentio included in his book the ideal design and dimensions that the Ragusan Niccolo Sagri proposed for a galleon, although both designs produced similar hull ratios. According to Crescentio, galleons were usually

[46] MNM. Col. Vargas Ponce, T. 3A Doc. 26 (30), fols. 144-155, in Hormaechea et al. 2012, 2:231.

designed using the traditional "*in terzo*" (1:3) rule that was the same as the *as-dos-tres* method, although in Crescentio and Sagri's designs, the depth of hold was only about half of the ship's breadth. The length-to-breadth ratios that resulted from Crescentio's dimensions ranged between 3:1 and 2.90:1, and depth of hold to breadth ratios between 0.51:1 and 0.48:1. Niccolo Sagri's dimensions, on the other hand, resulted in a length-to-breadth ratio of 3:1, and a depth of hold-to-breadth of 0.5:1 (Table 20).[47]

The Ordinances of 1607

Three different sets of shipbuilding Ordinances (*Ordenanzas*) were developed in Spain at the beginning of the 17th century to regulate the designs and tonnages of vessels that served in the Armada of the Ocean Sea (*Armada del Mar Oceáno*), and the Indies run (*Carrera de Indias*). These Ordinances, published in 1607, 1611, and 1613, were intended to define the most appropriate designs for both merchant and naval ships, and thereby to assist in meeting the crown's increasing need for ships to maintain communication between the different parts of its overseas empire, as well as to provide for its defense. The chronic shortage of *Armada* ships faced by the Spanish crown required vessels to be built in a way that they could be used as either warships or merchant vessels depending on the circumstances. Thus, the crown was able to press them into service (*embargo*) for its *armadas* in case of war or to escort the Indies fleets.[48] This objective could be behind the definition of a galleon as a multipurpose

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[47] Crescentio 1607, 63-5, 68-9.
[48] Apestegui, 2001; Fernández González 2012.

vessel. In fact, the Ordinances of 1607 and 1618 provided the same dimensions for all vessels irrespective of their function as warships or merchantmen.

The first set of Ordinances was issued in 1607, although it had to be modified four years later due to complaints received from shipwrights, who argued that the dimensions recommended led to the construction of flawed vessels.[49] The Ordinances classified the vessels as ships (*navíos*), small galleons (*galeoncetes*), and galleons (*galleons*) depending on their tonnages and breadths. The group of vessels with the closest breadths to the Apostles, between 17 and 21 cubits, appeared in the Ordinances classified as galleons. These galleons had length-to-breadth ratios that ranged from 3.53:1 for the 17-cubit breadth galleons to 3.43:1 for the 21-cubit breadth galleons, with an average ratio of 3.45:1. In addition, the depth of hold-to-breadth ratios varied from 0.54:1 to 0.51:1 for the same vessels with an average ratio of 0.53:1 (Table 21).[50]

Table 21. Dimensions and ratios of the 1607 Ordinances.

SOURCE	**YEAR**	**Length** Cubits	**Keel** Cubits	**Breadth** Cubits	**Main deck (DOH)** Cubits	**Maximum breadth (height)** Cubits	**L/B**	**DOH/B**
Ordenanzas	1607	60	43	17	9.25	9.25	3.53:1	0.54:1
Ordenanzas	1607	62	44	18	9.5	9.5	3.44:1	0.53:1
Ordenanzas	1607	65	47	19	10	10	3.42:1	0.53:1
Ordenanzas	1607	69	48	20	10.5	10.5	3.45:1	0.53:1
Ordenanzas	1607	72	51	21	11	11	3.43:1	0.52:1
AVERAGE	1607	-	-	-	-	-	3.45:1	0.53:1

[49] Phillips 1994, 108-9.
[50] Navarrete 1971, doc. 47, fols. 288-97.

Livro primeiro da architectura naval *(ca. 1608-16)*

In his unfinished shipbuilding manuscript, the Portuguese João Baptista Lavanha proposed the design of a four-decked merchant *nau* having a maximum breadth of 54 palms (*palmos*) (13.8 m) or 24 shipyard cubits (*codos de ribera*).[51] Lavanha's *nau* presented very conservative hull ratios with a length-to-breadth of only 3:1, and a depth of hold-to-breadth of 0.64:1 (Table 22).[52]

Table 22. Lavanha and Cano dimensions and ratios (1606-1611).

SOURCE	YEAR	**Length** Cubits	**Breadth** Cubits	**Main deck (DOH)** Cubits	**Maximum breadth (height)** Cubits	L/B	DOH/B
Lavanha (ca 1606-1618)	1606	162	54	30.98	34.5	3.00:1	0.64:1
Cano (Warship)	1611	46.5	12	7	6	3.88:1	0.50:1
Cano (Merchantman)	1611	49	12	6	7	4.08:1	0.58:1

Arte para fabricar y aparejar naos *(1611)*

In 1611, the captain Thomé Cano published his shipbuilding treatise *Arte para fabrica y aparejar naos*. In his work, Cano anticipated some of the modifications that would be introduced in the new set of Ordinances of 1613, such as the increase in keel length and rakes with respect to breadth.[53] Moreover, he was also the first author to mention the application of the *joba*, which determined the tilting of the head of the

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[51] Lavanha and Barker 1996, 130; 1 *palmo de goa* (0.256 m), 1 *codo de ribera* (0.575 m). Therefore, one *codo de ribera* equals 2.25 *palmos de goa*.
[52] Lavanha and Barker 1996, 36-7.
[53] Cano and Dorta1964, 24.

futtocks forward and aft of the master frame with respect to their lower part, without modifying their original curvature. The application of the *joba* increased the stability of the vessel, reducing its draft and need of ballast, while increasing the speed of the vessel. However, the use of the *joba* was probably introduced by Juan de Veas, one of the most prominent shipwrights of Spain during this period and one of the authors of the Ordinances of 1613.[54]

In his treatise, Cano proposed two different sets of dimensions for a *nao* (ship), depending on whether the vessel was designed as a warship or a merchantman. According to the dimensions proposed in his treatise, the warship would have a length-to-breadth ratio of 3.88:1, and a depth of hold-to-breadth of 0.5:1.[55] However, the most striking design provided by Cano is one for the merchantman that presented even more radical hull ratios than those of warships. The design of the merchantman had an even higher length-to-breadth ratio than of the warship at 4.08:1. In addition, the depth of hold-to-beam ratio also increased to 0.58:1 (Table 22).[56]

The Ordinances of 1613

A new set of Ordinances was issued in 1613 to correct the design flaws observed in the shipbuilding regulations of 1607, which had been severely criticized, especially by the officials of the House of Trade in Seville.[57] These *Ordenanzas* classified the vessels

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[54] Cano and Dorta 1964, 104-5; Gaztañeta et al. 1992, 1:22-3.
[55] Cano and Dorta 1964, 66-7.
[56] Cano and Dorta 1964, 91.
[57] Phillips 1994, 108-9.

as *pataches* (dispatch vessels), *navíos* (ships), and *galeones* (galleons) according to their breadth and tonnage. Ships with breadths ranging between 17 and 21 cubits, such as the Twelve Apostles, were classified as galleons, as in the previous set of Ordinances.[58] These regulations also established a maximum tonnage of 539 ¼ tons (toneladas) for galleons due to the sandbar situated at the mouth of the Guadalquivir River.[59] This maximum tonnage limited the draft of the ships sailing to and from Seville, the home port and final destination of the Indies Run.[60] In addition, this was the first set of Ordinances in which the values of the *joba* appeared regulated for each vessel depending on their breadths and tonnages.[61]

The designs proposed in the 1613 *Ordenanzas* distinguished between merchant and naval vessels based on the location of the ship's breadth. If the galleon was designed as a merchantman, the maximum breadth was placed at the same height as the main deck, but if designed as warship, the maximum breath was located ½ cubit below the main deck to ensure adequate height between the waterline and the gunports for the artillery.[62]

According to the Ordinances, the length-to-breadth ratios for the group of galleons with similar breadths to the Apostles ranged from 3.46:1 for the 17-cubit breadth galleons to 3.27:1 for the 21-cubit breadth, with an average ratio of 3.36:1, independent of whether they were designed as warships or merchant vessels. The depth

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[58] Serrano Mangas 1992, 211-22.
[59] Serrano Mangas 1992, 233.
[60] Parry 1990, 54.
[61] Serrano Mangas 1992, 212-22.
[62] Serrano Mangas 1992, 214-21.

of hold-to-breadth ratio varied minimally depending on the function of the galleon. The galleons conceived to carry cargo had a depth of hold-to-beam ratio of 0.5:1, while for warships the ratio ranged between 0.47:1 and 0.48:1 due to the variation in the height where the maximum breadth was situated (Table 23).[63]

Table 23. Dimensions and ratios of the 1613 Ordinances.

SOURCE	**Length** Cubit	**Keel** Cubit	**Breadth** Cubit	**Main deck (DOH)** Cubit	**Maximum breadth (height)** Cubit	L/B	DOH/B
*Ordenanzas*1613 (Warship)	58 3/4	46	17	8.5	8	3.46:1	0.47:1
Ordenanzas 1613 (Merchantman)	58 3/4	46	17	8.5	8.5	3.46:1	0.50:1
*Ordenanzas*1613 (Warship)	61 1/2	48	18	9	8.5	3.42:1	0.47:1
Ordenanzas 1613 (*Merchantman*)	61 1/2	48	18	9	9	3.42:1	0.50:1
Ordenanzas 1613 (Warship)	63 1/4	49	19	9.5	9	3.33:1	0.47:1
Ordenanzas 1613 (*Merchantman*)	63 1/4	49	19	9.5	9.5	3.33:1	0.50:1
Ordenanzas 1613 (Warship)	66	51	20	10	9.5	3.30:1	0.48:1
Ordenanzas 1613 (*Merchantman*)	66	51	20	10	10	3.30:1	0.50:1
Ordenanzas 1613 (Warship)	68 3/4	53	21	10.5	10	3.27:1	0.48:1
Ordenanzas 1613 (*Merchantman*)	68 3/4	53	21	10.5	10.5	3.27:1	0.50:1
Average Warships	-	-	-	-	-	3.36:1	0.47:1
Average Merchantmen	-	-	-	-	-	3.36:1	0.50:1

[63] Serrano Mangas 1992, 218-21.

The proposal of Captain Juan de Veas (ca. 1613-1618)

Captain Juan de Veas, one of the authors of the 1613 Ordinances and probably the shipwright who introduced the *joba* into Spanish shipbuilding tradition, committed himself to build six galleons and one large caravel (*carabelón*) in La Havana (Cuba). The set of dimensions he provided for these galleons showed length to beam ratio of 3.46:1, and a depth of hold-to-breadth ratio of 0.50:1 (Table 24).[64]

Table 24. Dimensions and ratios Juan de Veas and Fernandes (1613-1616).

SOURCE	YEAR	Length Cubits	Breadth Cubits	Main deck (DOH) Cubits	Maximum breadth (height) Cubits	L/B	DOH/B
6 galleons, Juan de Veas (1613-1618?)	1613	58 3/4	17	8.5	8.5	3.46:1	0.50:1
Fernandes, 4-decked carrack	1616	155	56	32	32	2.77:1	0.57:1
Fernandes, 300-ton Galleon	1616	118.33	38	18	18	3.11:1	0.47:1
Fernandes, 350-ton Galleon	1616	132.33	42	21.5	21.5	3.15:1	0.51:1
Fernandes, 500-ton Galleon	1616	140	46	22.5	22.5	3.04:1	0.49:1

Livro de Traças de Carpintaria *(1616)*

In his 1616 shipbuilding treatise *Livro de Traças de Carpintaria*, the Portuguese Manuel Fernandes described more than two dozen different ships. The ship types included in the treatise were a four-decked *nau* (carrack), galleons from 200 to 500 tons, *pataxes* (dispatch vessels), brigantines, *caravellas* (caravels), *galizabras*, *navíos* (ships),

[64] Navarrete 1971, 23, doc. 45, fols. 280-282, in Hormaechea et al. 2012, 2:278-80.

and *galés* (galleys), along with other smaller vessels.[65] For the purposes of this study, the four-decked *nau*, and the galleons of 300, 350, and 500 tons have been selected for comparing their ratios with those of the Apostles, since the *nau* was a large merchant vessels while the galleons were warships. Moreover, these four vessels also had breadths that were within the range of the Twelve Apostles (Table 24).

The dimensions that Fernandes provided for the four-decked *nau* resulted in a length-to-breadth ratio of only 2.72:1, and a depth of hold-to-breadth ratio of 0.57:1.[66] The 500-ton galleon presented the lowest length-to-breadth ratio of the three galleons with 3.04:1, while the 350-ton and 300-ton galleons increased their ratios up to 3.15:1 and 3.11:1. In other words, the smaller galleons had longer and narrower hulls. The variations of their depth of hold-to-breadth ratios, on the other hand, were minimal, with 0.49:1 for the 500-ton galleon, 0.51:1 for the 350-ton galleon, and 0.47:1 for the 300-ton galleon (Table 24).[67]

The Ordinances of 1618

A new set of Ordinances was issued in 1618 to once again correct the deficiencies observed in the ships built following the 1613 set of shipbuilding regulations. The new set of Ordinances would be in effect until the end of the century, although it underwent partial modifications in 1666 and 1679. Additionally, ships built

[65] Fernandes et al. 1995, 114-15.
[66] Fernandes et al. 1995, 117-19.
[67] Fernandes et al. 1995, 132, 137-39, 142.

after 1618 included modifications in their dimensions and other technical characteristics, as indicated in several contemporary shipbuilding contracts.[68] This new set of regulations classified all vessels as *navíos* (ships), and provided a unique design for them according to their breadths and tonnages, independently of their function as warship or merchantman.[69]

The length-to-breadth ratios produced by these Ordinances for ships with breadths within the range of the Apostles varied between 3.29:1 for the 17-cubit breadth ships and 3.27:1 of the 21-cubit breadth ones, with an average ratio of 3.22:1. The depth of hold-to-breadth ratios, on the other hand, ranged between 0.47:1 and 0.48:1, with an average of 0.47:1. The Ordinances also specified that all the vessels had their maximum breadth located ½ cubit below the main deck, as with the warship designs of the 1613 Ordinances (Table 25).[70]

Table 25. Dimensions and ratios of the 1618 Ordinances.

SOURCE	**YEAR**	**Length** Cubits	**Keel** Cubits	**Breadth** Cubits	**Main deck (DOH)** Cubits	**Maximum breadth (height)** Cubits	**L/B**	**DOH/B**
Ordenanzas	1618	56	44	17	8.5	8	3.29:1	0.47:1
Ordenanzas	1618	59	46	18	9	8.5	3.28:1	0.47:1
Ordenanzas	1618	61.5	48	19	9.5	9	3.24:1	0.47:1
Ordenanzas	1618	63	49	20	10	9.5	3.15:1	0.48:1
Ordenanzas	1618	66	51	21	10.5	10	3.14:1	0.48:1
Average	1618	-	-	-	-	-	3.22:1	0.47:1

[68] Phillips 1994, 110.
[69] Boix 1841, 4: 21-5.
[70] Boix 1841, 4:23-5.

Nuestra Señora del Juncal ***(1622)***

The galleon *Nuestra Señora del Juncal* was privately built as a merchant galleon in the shipyard of Fuenterrabía in 1622 by Antonio de Ubilla. The ship was probably built following the Ordinances of 1618. Once completed, *Nuestra Señora del Juncal* sailed as a merchant vessel to Veracruz (Mexico) with the New Spain Fleet of 1625. After this trip, it remained docked in Cádiz (Spain) until it was confiscated in 1629 to serve as the *Capitana* (Admiral) of the 1630 New Spain Fleet.[71] The galleon undertook several modifications and repairs to be adapted to its new naval function before departing for Veracruz where the New Spain Fleet remained for a year.[72] The fleet departed from Veracruz to Havana on 14 October 1631, but on the night of 31 October, *Nuestra Señora del Juncal* sank due to a storm.[73] The galleon had a length-to-breadth ratio of 3.18:1, and a depth of hold-to-breadth of 0.50:1 (Table 26).[74]

Martín de Arana construction of six galleons (1626-1627)

In 1626, the shipbuilder Martín de Arana signed a contract for the construction of six galleons for King Philip IV in the shipyard of Zorroza. According to the dimensions

[71] According to Trejo (2003, 86-9), the same year that *Nuestra Señora del Juncal* was built, Philip IV had ordered the construction of the Guipuzcoan Naval Squadron and offered loans to shipwrights for building and outfitting the ships. Nonetheless, according to the documentation available, Antonio de Ubilla never signed a contract with the crown to build *Nuestra Señora del Juncal*. This means that the ship was privately built. Consequently, *Nuestra Señora del Juncal* was probably designed as a merchant galleon. Naval galleons were normally built under a contract signed with the crown due to their higher cost in comparison to merchant ships.

[72] Meehan and Trejo 2008, 85-6.

[73] Trejo 2008, 238-40.

[74] Trejo 2003, 92.

given to Arana, the breadths of the galleons ranged between 14 and 17 cubits, and were to be built following the shipbuilding Ordinances of 1618. The document also introduced minor modifications with respect to the Ordinances, such as an increase of ½ cubit in the depth of hold. The 17-cubit breadth galleon presented a length-to-breadth ratio of only 3.29:1, while the depth of hold-to-breadth ratio was 0.50:1.[75]

Table 26. Ships' dimensions and ratios (1622-1627).

SOURCE	**Length** Cubits	**Breadth** Cubits	**Main deck (DOH)** Cubits	**Maximum breadth (height)** Cubits	**L/B**	**DOH/B**
Nuestra Señora del Juncal (1622-23)	60 1/3	19	9 1/2	9 1/2	3.18:1	0.50:1
Six galleons, Arana (1626)	56	17	8.5	8.5	3.29:1	0.50:1
San Felipe, Arana (1627)	56	18	8.5	8.5	3.11:1	0.47:1
Los Reyes, Arana (1627)	53 1/3	17	8	8	3.14:1	0.47:1
San Juan Bautista, Arana (1627)	53 1/2	17	8	8	3.15:1	0.47:1
Nra. Sra. De Begoña, Arana (1627)	56 3/4	18	8.5	8.5	3.15:1	0.47:1

However, a survey of these same galleons carried out in 1627 revealed several differences with respect to the dimensions specified in the original contract. For instance, the breadths of the as-built galleons ranged between 15 and 18 cubits, while their lengths were somewhat shortened. As a result of these variations, the length-to-

[75] MNM. Col. Vargas Ponce T. 3A Doc. 90 fol. 347, in Hormaechea et al. 2012, 2:303-4.

breadth ratios of the galleons with breadth between 17 and 18 cubits became 3.11:1 and 3.15:1. On the other hand, the depth of hold-to-breadth ratios became 0.47:1 for the same galleons, slightly lower than in their original design criteria (Table 26). [76]

Dialogo entre un Vizcayno y un Montañés sobre la fábrica de navíos *(ca. 1631-1632)*

In addition to the different sets of Ordinances issued in the early 17th century, other shipbuilding manuscripts were written recommending variations in the proportions and designs of the official shipbuilding Ordinances. One of the most important of these shipbuilding manuscripts was the *Diálogo entre un Vizcayno y un Montañés sobre la fábrica de navíos* (ca. 1631-1632). Despite there being no mention of the author in the manuscript, a study conducted by Vicente Maroto attributed its authorship to Pedro López de Soto. It should be noted that Pedro López de Soto was an experienced shipbuilder who built several galleons for Philip II in the late 16th century while he was the *veedor* (inspector) and *contador* (accountant) of the Armadas in Lisbon (Portugal).[77] The author also indicated in the manuscript that it was written to correct flaws observed in the galleons built following the 1618 Ordinances, although he did not specify exactly what those flaws were. Moreover, the designs proposed in the manuscripts were intended for building galleons that could serve in the Indies run and other locations, as

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[76] AGS GYM Leg 3149 n.2, in Hormaechea et al. 2012, 2:305-7.
[77] Vicente Maroto 1998, 23-6.

either warships or merchantmen, without having to be modified considerably or in an expensive way.[78]

In his manuscript, the length-to-breadth ratios of the group of galleons with breadths between 17 and 21 cubits were practically identical, ranging between 3.68:1 and 3.67:1, while their depth of hold to breadth ratios varied between 0.44:1 and 0.47:1. López de Soto's designs radically increased the length of the ship's hull in relation to its width, while its depth was further reduced (Table 27).[79]

Table 27. López de Soto dimensions and ratios (1631).

SOURCE	Length Cubits	Keel Cubits	Breadth Cubits	Main deck (DOH) Cubits	Maximum breadth (height) Cubits	L/B	DOH/B
López de Soto	62 1/2	51	17	9.5	7.5	3.68:1	0.44:1
López de Soto	66	54	18	10	8	3.67:1	0.44:1
López de Soto	69 2/3	57	19	10.5	9	3.67:1	0.47:1
López de Soto	73 1/3	60	20	11	9	3.67:1	0.45:1
López de Soto	77	63	21	11.5	9.5	3.67:1	0.45:1
López de Soto	80 2/3	66	22	12	10	3.67:1	0.45:1
Average	-	-	-	-	-	3.67:1	0.45:1

Arana's contract to build nine galleons (1632-1639)

In a new contract signed by Arana with the Spanish Crown in 1632 for the construction of nine new galleons, six of them with breadths between 17 and 18 cubits,

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[78] Vicente Maroto 1998, 179.
[79] Vicente Maroto 1998, 173-75.

the resulting length-to-breadth ratios increased up to 3.74:1 while the depth of hold-to-beam ratios ranged between 0.50:1 and 0.45:1.[80] However, according to a later document, the as-built galleons appeared slightly shorter than expected with only one of them with a ratio of 3.70:1, while the rest ranged between 3.38:1 and 3.56:1, and their depth of hold-to-breadth ratios ranged between 0.42:1 and 0.50:1 (Table 28).[81]

Table 28. Ships' dimensions and ratios (1632-1639).

SOURCE	**YEAR**	**Length** Cubits	**Breadth** Cubits	**Main deck (DOH)** Cubits	**Maximum breadth (height)** Cubits	**L/B**	**DOH/B**
Arana's contract to build 9 galleons. Three 700-ton galleons	1632	66	17 2/3	8 3/4	8 3/4	3.74:1	0.50:1
Arana's contract to build 9 galleons. Three 800-ton galleons	1632	69 3/4	18 2/3	9 1/3	8 1/3	3.74:1	0.45:1
Arana's contract to build 9 galleons *San Juan*	1634	64	18	9.00	9	3.56:1	0.50:1
Arana's contract to build 9 galleons. *San Mateo, San Marcos, San Lucas.*	1634	68.5	18 1/2	9 1/3	7 5/6	3.70:1	0.42:1
Arana's contract to build 9 galleons. *San Cristo de Burgos.*	1639	63 1/3	18 3/4	8.90	8 1/4	3.38:1	0.44:1
Francisco de Bustinsoro galleon. *San Francisco Capuchino*	1639	70 1/3	20 3/4	9 1/3	7 5/6	3.39:1	0.38:1
Arana's contract to build 9 galleons. *San Ambrosio*	1639	62 1/2	18 2/5	8 3/4	8 3/4	3.40:1	0.48:1
Arana's contract to build 9 galleons. *San Agustin*	1639	62 3/4	18 2/9	8.92	8 1/6	3.44:1	0.45:1
Arana's contract to build 9 galleons. *Santo Tomas De Aquino*	1639	62 3/4	18 1/6	8 2/5	7 2/3	3.45:1	0.42:1
Arana's contract to build 9 galleons. *San Geronimo*	1639	64 1/12	18 1/3	8 2/3	8	3.50:1	0.43:1
Francisco de Bustinsoro galleon. *Santa Maria Magdalena*	1639	71	20	9	7 3/4	3.54:1	0.39:1

[80] Frag. Doc. AGS Sección CMC 3a época Leg. 1791 n. 1, in Hormaechea et al. 2012, 2:325-26.
[81] This document includes the dimensions of the galleons built by Arana between 1634 and 1639 according to the contract signed in 1632, and two more galleons of F. de Bustinsoro. MNM. Col. Vargas Ponce T. XXVI Doc. 224, fol. 382, in Hormaechea et al. 2012, 2:328-30.

Francisco Díaz Pimienta designs (1645-1650)

The specifications that Pimienta provided in 1645 for a series of 18.5-cubit breadth galleons, to be built by Agustín de Barahona, presented a length-to-breadth ratio of 3.62:1, with a depth of hold that equaled half of the galleon's breadth (Table 29).[82]

Additionally, in 1650 Pimienta prepared another set of dimensions for a series of 500-ton galleons with a breadth of 17.5 cubits to be built for the Indies run. The resulting length-to-breadth ratio for these vessels was 3.54:1, and a depth of hold-to-breadth of 0.5:1. These specifications were modified and used by Grillo and Lomelin for the construction of another series of galleons in 1664. However, the modifications only affected the length of the floor, which was increased by 1/4 cubit, and the location of the ship's maximum breadth. Pimienta located the ship's breadth ½ cubit above the main deck, which after the modification of the ship's breadth, was extended from ½ cubit below the main deck to ½ cubit above it. Therefore, the length-to-breadth ratio of the galleons remained the same as in their original design but the depth of hold-to-breadth ratio was reduced to 0.44:1 (Table 29).[83]

Dimensions of various galleons (1650-1660)

The survey of a series of galleons with breadths between 17 and 19 cubits carried out between 1650 and 1660 showed vessels with length-to-breadth ratios between 3.35:1 and 3.55:1. The depth of hold-to-breadth ratios of these galleons also varied between

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[82] MNM. Col. Vargas Ponce T. 3A Doc 102 fol. 372-378, in Hormaechea et al. 2012, 2:336.
[83] MNM. Col. Vargas Ponce, T. XVII Doc. 34 fol. 58-59, in Hormaechea et al. 2012, 2:343-44.

0.48:1 and 0.50:1, except for the galleon *Nuestra Señora de Roncesvalles,* which revealed a ratio of only 0.35:1 (Table 29).[84]

Table 29. Ships' dimensions and ratios (1645-1660).

SOURCE	YEAR	**Length** Cubits	**Breadth** Cubits	**Main deck (DOH)** Cubits	**Maximum breadth (height)** Cubits	L/B	DOH/B
Pimienta's dimensions for the galleons to be built by Agustin de Barahona	1645	67	18 1/2	9 1/2	9 1/2	3.62:1	0.51:1
Dimensions of various galleons. (Luis de Cardona)	1650	63	18 5/6	8	9	3.35:1	0.48:1
Dimensions of various galleons. (Martin de Telleria)	1650	63 1/4	18 2/3	8 1/4	9 1/4	3.39:1	0.50:1
Dimensions of various galleons. (Francisco Navarro)	1650	65	19	8 1/4	9 1/4	3.42:1	0.49:1
Dimensions of various galleons. *Nra Sra de Roncesvalles*	1650	60	17 1/2	7 1/2	6 1/6	3.43:1	0.35:1
Dimensions of various galleons. (Gabriel de Curuzelaegui)	1650	65 65/97	18 6/7	8 1/4	9 1/4	3.48:1	0.49:1
Pimienta's dimensions for a 500-ton galleon (modified and used by Grillo and Lomelin in 1664).	1650	62	17 1/2	8 1/4	7 3/4	3.54:1	0.44:1
Pimienta's dimensions for a 500-ton galleon (modified and used by Grillo and Lomelin in 1664).	1650	62	17 1/2	8 1/4	8 3/4	3.54:1	0.50:1
Dimensions of various galleons. (Fernando Martel)	1650	63 1/2	17 8/9	8	9	3.55:1	0.50:1
Captain D. Juan Domingo de Echeverri. *Nra Sra de Roncesvalles*	1660	60	17 1/2	7 1/2	6 1/6	3.43:1	0.35:1

The Ordinances of 1666

In 1666, new sets of measurements were issued for galleons with breadths of 17.5 and 18 cubits in order to reduce their draft, allowing them to sail across the sandbar of Sanlúcar de Barrameda. The objective was to afford a more secure mooring area than

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[84] MNM. Col. Vargas Ponce T. 3A Doc. 111 fol. 398, in Hormaechea et al. 2012, 2:345; MNM. Col. Vargas Ponce T. XVII doc. 30 fol. 51, in Hormaechea et al. 2012, 2:364.

that provided by the Bay of Cadiz, where ships were less protected from enemy attacks and more susceptible to fraud and cargo robberies.

The modifications increased the galleons' hull lengths with respect to the dimensions proposed in the 1618 Ordinances for vessels with the same breadths. After the modification, the length-to-breadth ratio of a 17-cubit breadth galleons became 3.51:1, and 3.54:1 for the 18.5-cubit breadth ships. The depth of hold-to-breadth ratio, on the other hand, was only 0.47:1 in both cases (Table 30).[85]

Galleon **Nuestra Señora del Rosario y Arcángel San Gabriel** *(1667)*

The galleon *Nuestra Señora del Rosario* was built for the *Armada de la Guardia de las Indias* and, therefore, was likely conceived as a warship. The survey conducted in the shipyard of Mapil in Usurbil in 1667 showed that it had a length-to-breadth ratio of 3.48:1, while its depth of hold-to-breadth ratio was 0.49:1, since the maximum breadth was situated one cubit above the main deck (Table 30).[86]

Galleons **Santa Ana** *(Admiral) and* **Nuestra Señora de la Almudena** *(vice-Admiral) (1668)*

The galleon *Santa Ana* was surveyed in June, 1668, at the port of Pasajes, and its dimensions resulted in a length-to-breadth ratio of 3.57:1, and a depth of hold-to-breadth ratio of only 0.38:1. The following month the galleon *Nuestra Señora de la Almudena*

[85] Boix 1841, 4:32-3.
[86] MNM. Col. Vargas Ponce T. XVII, Doc. 255 fol. 44, in Hormaechea et al. 2012, 2:371.

was surveyed in Usurbil. According to its measurements, it had a length-to-breadth ratio of 3.60:1 while the depth of hold-to-breadth ratio was the same as that of *Santa Ana*. Since these galleons were referred to as Admiral and Vice-Admiral ships in the documentation, it is plausible to assume that both were designed as warships (Table 30).[87]

Table 30. Ships' dimensions and ratios (1666-1677).

SOURCE	YEAR	**Length** Cubits	**Breadth** Cubits	**Main deck (DOH)** Cubits	**Maximum breadth (height)** Cubits	L/B	DOH/B
Ordenanzas (1666)	1666	62	17.5	8.25	8.25	3.54:1	0.47:1
Ordenanzas (1666)	1666	65	18.5	8.75	8.75	3.51:1	0.47:1
Nra Sra Del Rosario Y Arcangel San Gabriel	1667	65 2/3	18 6/7	8 1/4	9 1/4	3.48:1	0.49:1
Santa Ana (*Capitana*)	1668	70 1/2	19 3/4	9	7 1/2	3.57:1	0.38:1
Nra Sra De La Almudena (*Almiranta*)	1668	67 6/7	18 7/8	8 2/3	7 1/6	3.60:1	0.38:1
Nra Sra De Atocha (Armada de la Guardia de las Indias)	1674	65	18 5/6	8 1/2	9	3.45:1	0.48:1
Navio Santa Rosa	1677	71 1/4	19 1/8	9	8	3.73:1	0.41:1

Galleon Nuestra Señora de Atocha *(1674)*

Nuestra Señora de Atocha was another galleon built for the *Armada de la Guardia de las Indias* and was, therefore, a warship, which was surveyed at the shipyard

[87] MNM. Col. Vargas Ponce, T. 3B Doc 12 fol. 56-57, in Hormaechea et al. 2012, 2:372.

of Mapil, in Usurbil, in 1674. The dimensions of this galleon revealed a length-to-breadth ratio 3.45:1, and a depth of hold-to-breadth ratio of 0.48:1 (Table 30).[88]

Ship (**navío*****)* Santa Rosa *(1678)***

Santa Rosa was surveyed in 1677 in Guarnizo by Captain Ignacio de Soroa. In his report, Soroa referred to the ship as a *navío* instead of as a galleon. It should be noted that the term *navío* was also used in the 1618 Ordinances to refer to all vessels, irrespective of their dimensions and tonnages. These were the same vessels that, in the previous sets of Ordinances, were defined as galleons, *galeoncetes*, or dispatch vessels depending on their breadths and tonnages. According to the survey of *Santa Rosa*, the length-to-breadth ratio was 3.73:1, and the depth of hold-to-breadth 0.41:1 (Table 30).[89]

The Ordinances of 1679

In 1679, another modification was applied to the Ordinances of 1618, although it only affected three-decked galleons with a 19-cubit breadth, similar to the breadth of the medium-sized Apostles. After this modification, the resulting length-to-breadth ratio was 3.55:1, nearly the same breadth as in the Ordinances of 1666, while the depth of hold-to-breadth ratio increased to 0.51:1 (Table 31).[90]

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[88] MNM. Col. Vargas Ponce T. XVIII Doc. 112 fol. 155, in Hormaechea et al. 2012, 2:382.
[89] MNM. Col. Sanz de Barutell Art. 4 n. 1523 fol. 243, in Hormaechea et al. 2012, 2:380.
[90] Boix 1841, 4:37-8.

Galleons built by Oquendo in Usúrbil (1680)

In 1680, Miguel de Oquendo was building four galleons in Usúrbil, an Admiral (*Capitana*), a Vice-Admiral (*Almiranta*), and two more galleons. The three largest galleons were surveyed in the shipyard, while the fourth vessel could not be measured since the bow had not yet been completed. The three galleons had breadths ranging between 20 cubits for the Admiral and 18.5 for the third largest ship. The Admiral and Vice-Admiral revealed a length-to-breadth ratio of 3.53:1 and 3.58:1, and the same depth of hold-to-breadth ratios of 0.46:1. The ratios of the third largest galleon were also similar to those of the previous ones since its length-to-breadth ratio was 3.57:1, and 0.45:1 for the depth of hold-to-breadth ratio (Table 31).[91]

Table 31. Ships' dimensions and ratios (1679-1682).

SOURCE	**YEAR**	**Length** Cubits	**Breadth** Cubits	**Main deck (DOH)** Cubits	**Maximum breadth (height)** Cubits	**L/B**	**DOH/B**
Ordenanzas (1679)	1679	67.5	19	9.25	9.75	3.55:1	0.51:1
Capitana Real	1680?	75 1/3	22 1/4	10 2/5	9	3.39:1	0.40:1
Dimensions of the four galleons built by Miguel de Oquendo in Usurbil in 1680 *Capitana* (Admiral)	1680	70.5	20	9 1/4	9 1/4	3.53:1	0.46:1
Dimensions of the four galleons built by Miguel de Oquendo in Usurbil. The largest of the other two.	1680	66	18.5	8 1/3	8 1/3	3.57:1	0.45:1
Dimensions of the four galleons built by Miguel de Oquendo in Usurbil. *Almiranta* (Vice-Admiral)	1680	68	19	8 2/3	8 2/3	3.58:1	0.46:1
Capitana Real Nuestra Señora de la Concepción y de las Animas	1682-1690	81 32/97	22.5	11.5	10.6	3.61:1	0.47:1

[91] MNM. Ms. 0087 bis, Doc. 17/28, in Hormaechea et al. 2012, 2:385.

*New Admiral (***Capitana Real***) built by Soroa (1680?)*

Another new Admiral's vessel, built by Captain Ignacio de Soroa, was surveyed in the port of Pasajes. According to the dimensions recorded, the length-to-breadth ratio was 3.39:1, and the depth of hold-to-breadth ratio was 0.40:1 (Table 31).[92]

Arte de fabricar reales *(1688)*

Despite the minor modifications introduced in 1666 and 1679, the shipbuilding Ordinances of 1618 were still valid at the end of the 17th century when Antonio de Gaztañeta wrote his *Arte de Fabricar Reales*, a manuscript on naval architecture and ship construction.[93] The manuscript focuses on the construction of the *Capitana Real de la Armada del mar Oceáno* (Admiral ship of the Royal Armada of the Ocean Sea), *Nuestra Señora de la Concepcion y de las Animas*, built in the shipyard of Colindres between 1682 and 1690, and the galleon *San Francisco* for the Silver run (*la Carrera de la Plata*).[94] Based on the dimensions that Gaztañeta provided in his manuscript, the length-to-breadth ratio of *Nuestra Señora de la Concepcion y de las Animas* was 3.61:1, with a depth of hold-to-breadth ratio of 0.47:1 (Table 31). [95]

[92] MNM. Vargas Ponce T. XVIII doc. 150 fol. 196 bis, in Hormaechea et al. 2012, 2:386.
[93] Gaztañeta et al. 1992, 1:3.
[94] Gaztañeta et al. 1992, 1:7, 13.
[95] Gaztañeta et al 1992, 1:81-2.

Recopilación para la nueva fábrica de baxeles españoles *(1691)*

In 1691, Francisco Antonio Garrote wrote a manuscript in which he provided his own solution to solve the problem of simultaneously strengthening the hulls of ships while reducing their drafts in order to safely cross the Sanlúcar sandbar at the mouth of the Guadalquivir River.[96]

In his manuscript, Garrote proposed a set of main dimensions to build warships for the Armadas of the Ocean Sea that could also serve as merchantmen for the Indies run.[97] In other words, he proposed designs for ships to serve as multipurpose vessels. Garrote classified the ships in six classes (*órdenes*) depending on their breadths. The classes with the most similar breadths to the Apostles were the second to the fifth, with breadths between 16 and 22 in two cubits intervals. All these classes had the same length-to-breadth and depth of hold to beam ratios of 3.44:1 and 0.40:1 (Table 32).[98]

Galleons* San José *and* San Joaquín *(1698)

Finally, *San José* and *San Joaquín*, built in 1698, were the last two galleons built in Spain before the advent of the ship of the line. It should be noted that the length-to-breadth ratios of these galleons were very conservative in comparison to other contemporary vessels, at only 3.23:1 and 3.25:1, which matched the requirements of the

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[96] Garrote (1691), in Artíñano y de Galdácano 1920, 123.
[97] Garrote (1691), in Artíñano y de Galdácano 1920, 322.
[98] Garrote (1691), in Artíñano y de Galdácano 1920, 325.

1618 Ordinances. In contrast, their depth of hold-to-breadth ratio was 0.45:1 (Table 32).[99]

Table 32. Ships' dimensions and ratios (1691-1698).

SOURCE	YEAR	Length Cubits	Breadth Cubits	Main deck (DOH) Cubits	Maximum breadth (height) Cubits	L/B	DOH/B
Garrote	1691	55	16	6 3/8	6 3/8	3.44:1	0.40:1
Garrote	1691	61 11/12	18	7 1/6	7 1/6	3.44:1	0.40:1
Garrote	1691	68 5/6	20	8	8	3.44:1	0.40:1
Garrote	1691	75 17/24	22	8 19/24	8 19/24	3.44:1	0.40:1
Average (Garrote)	-	-	-	-	-	3.44:1	0.40:1
San Joaquin	1698	71	22	10	10	3.23:1	0.45:1
San Jose	1698	71.2	21.9	10	10	3.25:1	0.46:1

Analysis of the evolution of the hull ratios in Spain (1550-1698)

The analysis of the variations in the hull ratios observed in shipbuilding treatises, manuscripts, design reports, and ship surveys shows that since the second half of the 16th century there was an evolution of the hull proportions depending on the ship function. However, these variations are not as accentuated as might be expected when taking into account the simultaneous changes occurring in the designs of the vessels. While there was a clear difference between ship hull ratios depending on their function as warship or merchant vessel since the mid-16th century, these difference become less clear during the

[99] Phillips 2007, 12.

17th century. However, despite the changes observed in the hull ratios of vessels since the mid-16th century until the end of the 17th century, in which the hull became longer, narrower, and lower, the differences between warships and merchantmen become less clear during the 17th century and closer to the warship design of the 16th century.

Instructione sul modo di fabricare galere *(ca. 1550)*

In his *Instructione*, Pre Teodoro de Niccoló was one of the first authors to clearly differentiate the hull ratios of a galleon based on its function as a warship or a merchantman. When compared to the different designs proposed for the Apostles, only Barros's length-to-breadth ratios for the medium-sized and large Apostles were similar to the ratios that Pre Teodoro recommended for warships, although Barros's design produced deeper hulls. In contrast, the hull ratios of the committee's final report were closer to Pre Teodoro's proportions for merchantmen than for warships. The same occurred with the ratios of the three galleons surveyed in Portugalete in 1592, whose proportions followed closely those of Pre Teodoro's *navi*, especially in the case of *San Matías*. In other words, the specialized design of the Apostles as warships was more similar to Pre Teodoro's ideal dimensions for Mediterranean merchant vessels than warships.

It should be noted that the only galleons built in the shipyards of northern Spain that show length-to-breadth ratios similar to Pre Teodoro's warships were Menéndez's *galeoncetes* and the galleons built by Barros in Guarnizo. On the other hand, the ships built in the shipyards of the Italian Peninsula that took part in the Spanish Armada, and even the majority of ships of the later Illyrian squadron, had shorter length-to-breadth and deeper depth of hold-to-breadth ratios than those proposed by Teodoro for merchant vessels.

The 24M vessel at Red Bay (1565)

The analysis of the dimensions and ratios of the 24M vessel at Red Bay show a design that fits within the proportions expected for a 16th-century merchant vessel, although slightly lower than usual for this period and its function. Only the Mediterranean design for merchantmen or multipurpose vessels of the later 16th century and early 17th century show comparable depth of hold-to-breadth ratios. These vessels had depths of hold that equaled half of their breadth, although they were also slightly longer and narrower, with length-to-breadth ratios between 2.9:1 and 3.1:1, such as those of Pre Theodoro, Crescentio, and Sagri.

According to its ratios, the hull of the Red Bay vessel was proportionally shorter and wider than the design values proposed for the Twelve Apostles, including Barros's proportions for merchantmen, although similar to the ratios of his small galleons. The only Apostle with a similar length-to-breadth ratio was *San Tadeo*, although its ratio was lower than expected since the original design proposed a longer hull. The length-to-breadth ratio of the 24M vessel, on the other hand, was very similar to those of the Mediterranean *navi* that took part in the Spanish Armada of 1588, several of the Illyrian galleons, and even Oliveira's design for his *nau,* despite the different sizes of vessels. The only warship with a similar hull ratio was *San Juan Evangelista*, built at the end of the 16th century, although its ratios were closer to the hull proportions conceived for merchant vessels than for warships designed in the second half of the 16th century, and especially during the 17th-century.

However, the 24M vessel presented a depth of hold-to-breadth ratio of only 0.53:1, almost equal to half of its breadth, and similar to the ratios of 17th-century galleons, as well as those given in shipbuilding treatises and manuscripts. Therefore, although its hull was proportionally shorter than that of the Apostles, it was also lower since their depths of hold were normally slightly above 2/3 of their breadths. In fact, the only designs of the Apostles with a similar depth of hold-to-breadth ratio were those proposed by Luis César. The only 16th-century vessels or design with comparable ratios are a few units of the Illyrian squadron.

The* galeoncetes *of Pedro Menéndez de Avilés (1568)

The comparison of the ratios of Menéndez's *galeoncetes* with those of the Twelve Apostles reveals that the *galeoncetes* were proportionally much longer and narrower than the Apostles, even according to Barros's designs, and only comparable to Cesar's proposal for the 600-ton galleon. It must be noted that Menéndez's vessels were conceived as warships, and their high length-to-breadth ratios resulted from their design as galley-like galleons (*agalerados*) to increase their maneuverability and speed under oar and sail.

Their theoretical depth of hold-to-breadth ratio was also similar to the final design proposal for the Twelve Apostles, except for the small ships, and even slightly deeper than that of the galleons surveyed in 1592. Moreover, the ratios that resulted from the 1571 survey showed proportionally deeper galleons than the Apostles, even according to Barros's design for warships. However, their deep drafts, which resulted from their specific hull design, necessitated closing the gunports of the main deck in windy conditions to prevent seawater from entering the vessels. Additionally, their deep draft also made the use of oars impossible. Nevertheless, the design specifications of Menéndez's *galeoncetes* corresponded well with the ratios expected for a warship, and supports their description as galley-like galleons of new invention. However, their design also resulted in the production of ships with such deep drafts that artillery on the main deck was useless in unfavorable weather conditions, while additionally limiting the ship's capacity to carry provisions and troops.

Itinerario de Navegación de los mares y tierras occidentales *(1575)*

The length-to-breadth ratio that Escalante proposed in his *Itinerario* for a multipurpose vessel was similar to that of the committee's final design for the Apostles. However, this ratio was still lower in comparison to those of Menéndez's *galeoncetes*, Barros's galleasses, and to his earlier series of galleons, which were designed specifically as warships. In any case, this value was still higher than the average ratio for merchant ships such as the Cantabrian *naos* and the Mediterranean *navi* that took part in the Great Armada of 1588.

Barros's galleasses (1578)

The main dimensions of the galleass *San Cristóbal* were almost identical to the ones that Barros proposed for the medium-sized galleons when designed as warships, although the latter had a length one cubit shorter and ½ cubit narrower. The hull proportions of the galleasses, however, revealed longer and narrower hulls than the final designs of the committee of shipwrights for the Apostles. In addition, the depth of hold-to-breadth ratio of the galleass was similar to the final design of the Apostles, especially to the large galleons, although the three galleons surveyed in Portugalete in 1592 presented lower ratios. In any case, despite Barros's claims about the qualities of his design and according to the members of the committee who designed the Twelve Apostles, the galleass *San Cristóbal* was too narrow and drew more water than expected.

Livro da fabrica das naus *(1580)*

The actual length-to-breadth ratio of Oliveira's merchant *nau* is comparable to the proportions of the hulls of the three Apostles surveyed in Portugalete in 1592, although they turned out to be lower than the final designs of the shipwrights' committee. However, this ratio results in a much lower value in comparison to those of the previous galleons and galleasses that Menéndez and Barros designed and built specifically as warships. On the other hand, the Mediterranean *navi* that took part in the 1588 Armada, as well as the later Mediterranean galleons of the Illyrian squadron, have a closer length-to-breadth ratio to that of Oliveira's *nau*. Nevertheless, despite the hull of Oliveira's *nau* being shorter and wider than the warships designs, it was also lower since the resulting depth of hold-to-breadth ratio was less than half of its maximum breadth, while in the other designs it always equaled approximately 2/3 of the ship's breadth.

The galleons of Cristóbal de Barros (1581)

The analysis of the ratios resulting from the original design of these galleons, and those resulting from the 1588 survey, reveals longer and narrower hulls than the designs that the committee proposed for the Twelve Apostles. The galleons with the closest length-to-breadth ratios to this series of galleons are precisely Barros's later warship designs for the medium and large Apostles, although they still showed lower values. However, none of the length-to-breadth ratios that resulted from the final designs of the Apostles were similar to those of the previous series of galleons, except for César's design of the 600-ton galleons. Barros's earlier galleons were also lower than any of the Twelve Apostles' designs, although according to the 1588 survey, their depth of hold-to-breadth ratios became almost identical to the ratios of the Apostle designs, and even deeper than the three Apostles surveyed in 1592.

The main design flaw of Barros's earlier galleons resulted from their long and narrow hulls, which contributed to their deep draft. As a result of this situation, the vessels were often unable to use the main deck ordnance due to their deep draft, as was the case in Menéndez's galleons. Additionally, the draft of Barros's galleons also prevented them from sailing over the sandbar at the mouth of the Guadalquivir during low tide because these galleons, even the smaller ones, drew 11 cubits (6.33 m) of water.[100] It should also be noted that, despite their design flaws, eight of these galleons formed the core of the Squadron of Castile that took part in the ill-fated expedition against England in 1588; all of them subsequently returned safely to Spain despite the storms that decimated the Armada. Nevertheless, Barros's galleons were cited during the design process of the Twelve Apostles as an example of what needed to be avoided during the design of the new vessels.

Instrucción Náutica *(1587)*

The length-to-breadth ratio of Palacio's multipurpose *nao* is similar to the final designs of the Twelve Apostles, especially in the case of the small and medium-sized galleons, including *San Bartolomé* after its construction, although varying from the other two galleons surveyed in Portugalete in 1592. Palacio's ratio is also similar to the one proposed by Escalante in his design of a *nao,* lower than those of the previous warship designs by Menéndez and Barros, and comparable to those used in the design of the Apostles. In any case, Palacio's proposal shows a *nao* with a longer and narrower hull than the typical Cantabrian *naos* and Mediterranean *navi* of the 1588 Armada, and the later Illyrian galleons. Ultimately, Palacio's design defines a sleeker hull in comparison to the traditional proportions applied in the design of merchant vessels, but still shorter than the proper warships built in Spain before the Apostles.

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[100] AGS GYM Leg. 245 doc. 11.

Palacio's design, on the other hand, presented one of the lowest depth of hold-to-breadth ratios of all 16th- and 17th-centuries designs of either merchantmen or warships. This ratio was similar to Pre Teodoro's design for warships but also to Oliveira's *nau*, as well as to the average ratios of different 17th-century shipbuilding ordinances and manuscripts issued in Spain, and several galleons built during the same period. It should be noted that the majority of 16th-century merchant and warship designs, such as the Apostles, had depth of hold-to-breadth ratios that ranged between 0.60:1 and 0.70:1, independent of their function.

Ships of the Great Armada (1588)

With respect to the different types of ships that took part in the Great Armada of 1588, the Levantine *navi* were shorter and wider than the designs that the committee of shipwrights and Barros proposed for the Twelve Apostles. In fact, the only Apostles with similar length-to-breadth ratios to the Levantine vessels were Barros's designs for the small Apostles, and *San Tadeo,* according to the survey conducted in 1592. However, the length-to-breadth ratios of the Levantine *navi* were even lower than Barros's merchantmen designs for the Apostles, and the traditional 1:3 ratio that regulated Mediterranean design according to Cano and Crescentio. The average depth of hold-to-breadth ratio of the Levantine vessels was very similar to the proportions measured during the 1592 survey of the three Apostles, but lower than in the designs proposed for the Apostles, especially in the case of the final design for the medium and large galleons.

The ratios of the Cantabrian *naos* were very similar to the designs that Barros proposed for the Apostles as merchant vessels, although the depth of hold-to-breadth ratio was almost identical to those of warship designs prepared by Barros, and also to those of the committee of shipwrights. It should also be noted that the individual length-to-breadth ratios of the *naos* varied between 3.17:1 and 3:1. This shows that the differences between the hull proportions of the *naos* designed as merchantmen and the final designs of the Apostles as warships were not as markedly different as might be expected between vessels with such different functions.

The French and the Florentine galleons were much longer and narrower than the Apostles, including Barros's warship design for the Apostles or even his previous series of galleons. Moreover, their depth of hold-to-breadth ratios were relatively deeper, especially in the case of the galleon of the Duke of Florence, similar to that of the Apostles surveyed in Portugalete in 1592, although lower than the Apostle designs. Interestingly, the ratios of the private Spanish galleon that took part in the 1588 Armada show a sleeker hull than the Apostles, similar to Palacio's *nao* but still proportionally as deep as the Apostles.

The comparative analysis of the hull ratios of the different types of ships that took part in the Great Armada of 1588 reveals that the vessels with the closer ratios to the Apostles were the *naos* built in the shipyards of northern Spain. In fact, the hull ratios of the Apostles were more similar to the *naos* than to those of the galleons or warships of the Armada of 1588. On the other hand, the Levantine *navi* had the closest hull ratios to the traditional design rule of *As-Dos-Tres*.

The Twelve Apostles (1589-1592)

The comparative analysis of the hull ratios that resulted from the different design proposals for the Twelve Apostles reveals minor differences between the different designs except in the case of Barros's design of the galleons as merchantmen. Unfortunately, the first design proposal of the committee of shipwrights did not include the lengths of the vessels and, therefore, it is impossible to prove Barros's accusation that the Apostles were designed as merchantmen. However, these designs still provided the breadth and depth of hold and, therefore, it was possible to calculate the depth-of-hold to breadth ratios, which were not very different from those proposed by Barros or from the final design produced by the committee of shipwrights for the Apostles. Moreover, these ratios, which calculate to slightly above 2/3, were within the normal ratios employed in the previous series of galleons and galleasses built in Spain during the second half of the 16th century.

Luis César's design review did allow the calculation of both the length-to-breadth and depth of hold-to-breadth ratios of the galleons. Interestingly, his 600-ton galleons were to have long and narrow hulls similar to the earlier series of galleons built by Menéndez and Barros, and the later Spanish designs of the second half of the 17th century. The 500-ton galleons, on the other hand, presented a ratio similar to final designs proposed for the Twelve Apostles by the shipwrights committee. In any case, Cesar's designs produced considerably lower hulls than those in the first proposals for the Apostles, with depths of hold that were almost equal to half of the ship's breadth instead of 2/3.

In contrast, Barros's dimensions for the small galleons increased the depth of hold-to-breadth ratio in relation to the first design of the committee of shipwrights, while the ratios of the medium-sized and large Apostles were identical to those of the committee's design. In addition, the function of the vessel did not affect this ratio for the galleons, since it remained the same independent of whether the galleons were conceived as warships or merchantmen. Barros's dimensions also produced shorter but deeper hulls than César's, especially in the case of the small galleons, even though they were designed as warships.

The final design of the Twelve Apostles from the committee proposed longer and narrower hulls than Barros did for the small galleons; in fact, the committee's proportions were almost identical to César's proportions for the 500-ton galleons, with a length-to-breadth ratio of 3.18:1. The committee also maintained the original depth of hold-to-breadth ratio of 0.62:1, which was slightly less than Barros's ratio but still greater than César's design. The medium-sized and large galleons presented length-to-breadth ratios of 3.19:1 and 3.12:1, which were slightly higher than Barros's ratios for the galleons designed as merchantmen, but lower in comparison to his ratios for the warships. In other words, the committee's designs represented an intermediate stage between the merchantmen and warships ratios proposed by Barros. Interestingly, the committee's designs also kept the same depth of hold-to-breadth ratios as Barros's designs with values of 0.68:1 and 0.66:1. However, when the ratios of the large galleons were compared to César's designs, the hulls of the Apostles were proportionally wider, shorter, and deeper.

Finally, there were also variations between the ratios that resulted from the final design proposal for the Apostles and the actual ratios of the galleons after their construction, as the survey of the Apostles *San Mateo*, *San Tadeo*, and *San Bartolomé* revealed in 1592. For instance, *San Tadeo*'s length-to-breadth ratio fell well below the theoretical ratio of the committee's final design report for the medium-sized galleons, and even from Barros's design for merchant vessels. This meant that the galleon as-built was much shorter and wider than initially proposed, even if it had been designed as a merchant vessel. This ship not only became shorter and wider than originally intended, but also slightly lower. In contrast, the length-to-breadth ratios of *San Matías* and *San Bartolomé* were almost identical to that indicated in the committee's report for the large galleons, while the as-built hulls of all three galleons were lower than in their original designs. In any case, their depths of hold were never lower than 2/3 of their breadth, as given in the original designs, except for the proposal of Luis César. The differences observed between the theoretical and real ratios of the Apostles are related to construction methods used by the carpenters, which depended greatly on tradition and craftsmanship as several contemporary reports indicated.

In order to evaluate if the hull ratios of the Apostles corresponded to their function as warships and not as merchantmen as Barros claimed, it is necessary to compare these ratios with those proposed in 16th-and 17th-century shipbuilding treatises and manuscripts as well as against other warships and merchantmen built during the same period.

The Illyrian squadron (1595)

The average length-to-breadth ratio of the Illyrian galleons was lower than those of the Apostles although their depth of hold-to-breadth ratio was very similar. Basically, the galleons of the Illyrian squadron had shorter and wider hulls but were almost as deep as the Apostles. Only Barros's merchant designs for the Apostles were similar to the ratios of the Illyrian vessels. Moreover, these ratios were far from those of the Atlantic-built galleons of the Great Armada. In fact, the length-to-breadth ratios of the Illyrian galleons were even smaller than the values for the Cantabrian merchant *naos*. The only ships that showed similar hull proportions were, again, the *navi* of the Levantine squadron.

Despite Ivella's claims about the design of his galleons as oceangoing warships, their length-to-breadth ratios were lower than what 16^{th}- and 17^{th}-centuries Italian and Spanish authors recommended for merchant ships, and even deeper than the ideal Spanish proportions for oceangoing merchant ships. For instance, Pre Theodoro proposed in his *Instructione* (ca. 1550) a length-to-breadth ratio of 3.1:1 and depth of hold-to-breadth of 0.5:1 for merchant galleons, but 3.6:1 and 0.45:1 for warships. In his *Nautica Mediterranea* (1607), Crescentio also mentioned similar ratios with a length-to-breadth of 3:1 and a depth of hold-to-breadth of 0.5:1. In Spain, Escalante (1575) and Palacio (1587) suggested longer, narrower, and lower vessels than did the Italians, with length-to-breadth ratios of 3.18:1 and 3.21:1, and in the case of Palacio a depth of hold-to-breadth ratio of 0.47:1, although these ratios were valid for both merchant vessels and warships.

San Juan Evangelista *(1599)*

The ratios of the galleon *San Juan Evangelista* revealed a shorter and wider hull than the Apostles but also lower, although its length-to-breadth ratio was similar to the Apostle *San Tadeo* surveyed in Portugalete in 1592. Nevertheless, this ratio was still lower than the design for merchant vessels proposed by Barros for the Apostles, and even the merchant *naos* that took part in the Armada of 1588. Interestingly, the vessels with the closest hull proportions to this galleon were the Mediterranean-built *navi* of the 1588 Armada and the galleons of the Illyrian squadron. Its depth of hold-to-breadth ratio was higher than the three Apostles surveyed in 1592, although lower than the original design for the large and medium-sized Apostles. Finally, the hull proportions of *San Juan Evangelista* were also very close to the traditional *as-dos-tres* rule, but very different from the ratios of Menéndez's galleons, and the galleasses and galleons designed as warships by Barros. The ratios of the Apostles would be half way between these designs despite being conceived as warships.

Nautica Mediterranea *(1607)*

The hull ratios recommended in the treatise *Nautica Mediterranea* were the same as those in the earlier design of Pre Theodoro for a merchant galleon. These length-to-breadth ratios were shorter than the ones proposed in the final designs of the committee of shipwrights for the Apostles, although almost equal to Barros's design for merchant vessels. The actual dimensions of the Apostle *San Tadeo*, as surveyed in 1592, and even the later *San Juan Evangelista*, also fit within the range of these ratios. However, the

Levantine *navi* of the Great Armada and the later Illyrian galleons comprised the groups of vessels with the closest length-to-breadth ratios to Crescentio and Sagri's designs. Their designs not only showed shorter and wider hulls with respect to the Apostles, but were also lower since the depth of hold-to-breadth ratio were only half of their breadth and not 2/3 as in the other designs. This ratio, however, was comparable to those used in Spanish ship design during the 17th century for both warships and merchant vessels.

The Ordinances of 1607

The Ordinances of 1607 increased the length-to-breadth ratio of vessels in relation to the 16th-century designs to produce faster and more maneuverable vessels. However, this variation produced unstable ships. Additionally, the depth of hold-to-breadth ratio was also reduced and became almost half of the ship's breadth, as in Theodoro, Crescentio, and Sagri's designs. In other words, the galleons designed at the beginning of the 17th century had longer, narrower, and lower hulls than those of the previous, 16th-century series.

When comparing the hull ratios of the Apostles with those provided by the 1607 Ordinances, it is clear that the latter advocated for longer and more slender ships than the designers of the Apostles. The ratios of the Apostles are much lower than those of the Ordinances, including Barros's design for the Apostles as warships, although his proposal closely mirrored the length-to-breadth ratios of the Ordinances.

The dimensions proposed in the 1607 Ordinances represent a new conception for the galleons built in Spain, independent of their function. The new designs produced longer and narrower hulls with length-to-breadth ratios similar to the earlier series of warships built by Menéndez and Barros in the second half of the 16th century, although the new designs also showed a reduction in the depth of hulls. The new designs eliminated the orlop deck, or at least did not mention it, although they did maintain a row of unplanked beams. However, as in the case of the first series of galleons built by Barros in Guarnizo, the new designs also presented stability issues caused by their long and sleek hulls. Additionally, these new designs also deviated from the Cantabrian merchant *naos* and the 16th-century Mediterranean design.

Livro primeiro da architectura naval *(ca. 1608-16)*

The hull ratios of Lavanha's four-decked merchant *nau* are practically equal to the merchant designs that Barros proposed for the Apostles since this was a *nau* specifically designed for cargo. In addition, its length-to-breadth ratio was identical or very close to the ratios of the Mediterranean *navi* of the 1588 Armada, the Illyrian galleons, and Crescentio and Sagri's designs, although the first presented a lower depth of hold-to-breadth ratios. This ratio was almost indistinguishable from those of the final designs of the Apostles, as well as Menéndez's and Barros's galleons. In fact, according to this analysis, the only difference between the hull proportions of Lavanha's *nau* and the galleons designed as warships in Spain was that the former had longer and narrower hulls, while the depth of hold-to-breadth ratio was almost the same in all cases.

Arte para fabricar y aparejar naos *(1611)*

The length-to-breadth ratio for a warship recommended in Cano's treatise, *Arte para fabricar y aparejar naos,* exceeded any design proposed for the Apostles, including Barros's, those of the earlier series of galleons designed specifically as warships, and the flawed designs proposed in the original set of Ordinances of 1607. The hull of Cano's warship was also lower than any of the previous designs in Spain, apart from those specified in the 1607 Ordinances. Cano's design would clearly produce a much longer, narrower, and lower vessel than the Apostles. However, Cano's design for a merchant vessel presented an even higher length-to-breadth ratio than for the warship although its depth of hold-to-breadth ratio was also increased to nearly equal 2/3 of its breadth as in the previous 16th-century designs.

The Ordinances of 1613

The analysis of the dimensions and ratios listed in the new *Ordenanzas* issued in 1613 shows a reduction of the ships' lengths in comparison to the previous set of 1607, while the depth of hold became equal to half of the ship's breadth, or even slightly lower in the warship designs. This confirmed the tendency initiated with the 1607 Ordinances to build lower and wider hulls to reduce ship's draft and height.

The comparison of the average ratios of the designs proposed in the 1613 Ordinances reveals slightly shorter and wider galleons than in the previous set of Ordinances, in order to correct their design flaws. Nevertheless, the length-to-breadth ratios are still higher than the ones proposed for the final design of the Apostles. The galleons of the 1613 Ordinances were longer, narrower, and lower than the Apostles, especially in comparison with Barros's merchantmen designs. However, the ratios of the designs that Barros proposed for the Apostles as warships were almost identical to the ratios of the 1613 Ordinances in the case of the medium-sized galleons, but slightly higher for the large ones. In any case, the Apostles were built according to the committee's design, which resulted in even shorter and wider vessels. In comparison to the 1613 Ordinances, the Apostles' final length-to-breadth ratios were even lower than the ratios proposed for merchant vessels, with a deeper hold to carry more cargo. It should be noted that the length-to-breadth ratios in the 1613 Ordinances were also shorter than the ratios for warships built by Menendez and Barros during the second half of the 16th century, although the new ships were considerably lower.

This new set of Ordinances shortened the hulls with respect to the 1607 Ordinances, and lowered the depth of hold-to-breadth ratios to build more stable vessels. The resulting design was still slender enough to make them sufficiently fast and maneuverable if the vessels were designed as warships, with a minimum increase in the ship's depth of hold if built as merchantmen.

The proposal of Captain Juan de Veas (ca. 1613-1618)

There are no variations between the ratios of the galleons to be built by Juan de Veas in La Havana and those that resulted from the 1613 Ordinances for the galleons with similar dimensions. Therefore, the regulations of the Ordinances appear to be applied directly, at least in the case of the design report for this series of galleons.

Livro de Traças de Carpintaria *(1616)*

The length-to-breadth ratio of Fernandes's *nau* was within the same range as that of the Mediterranean galleons of the Illyrian squadron. The only Apostles design that presented comparable ratios was the one that Barros proposed for the small galleons, although the actual ratios of *San Tadeo* were also similar. In any case, the length-to-breadth ratio of the *nau* was much lower than the ones proposed for the final design of the Apostles. The *nau* also had a slightly lower depth of hold-to-breadth ratio in comparison to the Apostles, as it corresponded to the new, 17th-century ship designs. On the other hand, the ratios of the late 16th-century galleon *San Juan Evangelista* were not much different from those of the *nau*. It should be noted that Fernandes's *nau* presented a shorter hull with respect to their breadth in comparison to both Oliveira and Lavanha's designs for *naus*, although only Oliveira's design showed a lower hull, while Lavanha's maintained the traditional proportion of the depth of hold, which almost equaled 2/3 of the breadth. These designs are another example of how at the beginning of the 17th century, the depths of hold shrank to become half of the hull breadths instead of 2/3.

While the *nau* was the typical merchant ship, which could also be armed in case of need, it was not designed as a warship such as the galleons conceived specifically for naval warfare. Fernandes's design for the 500-ton galleon had a length-to-breadth ratio very similar to some of the Illyrian galleons, including the squadron Admiral's ship *San Girolamo*, and the Cantabrian *naos* of the Armada of 1588. However, the only Apostles designed with comparable length-to-breadth ratios were those of Barros's for the

Apostles designed as merchantmen. In any case, the main difference between Fernandes's 500-ton galleon and the aforementioned vessels was their lower hull.

The two smaller Fernandes's galleon designs had length-to-breadth ratios not only close to the final designs of the Apostles, and even *San Matías* in 1592, but also to the galleons built in Spain in the first third of the 17th century, and the ratios resulting from the forthcoming 1618 shipbuilding Ordinances. The main difference, however, between Fernandes's galleons and the Apostles was, again, related to their depth of hold-to-breadth ratio, which was only half of the ship's breadth, instead of more than 2/3 as with the case of the Apostles and the other vessels built during the second half of the 16th century. In any case, the Fernandes galleons have similar hull proportions to the Apostles in relation to their lengths and narrowness, although they were also lower. Additionally, Fernandes's ratios were comparable to Pre Theodoro's mid-16th century recommendations for merchant vessels. Nevertheless, these ratios correspond to the multipurpose galleons built in Spain during the first third of the 17th century, which were designed to be used primarily as warships but could also be employed as merchant vessels on the Indies run if required.

The Ordinances of 1618

The examination of the resulting ratios of the 1618 Ordinances reveals that the reduction of the length-to-breadth and the depth of hold-to-breadth ratios continued in comparison to the warship designs of the 1613 Ordinances, with the ship's depth of hold becoming slightly lower. Ultimately these ships became shorter and wider than the 1613 vessels, but as low as the previous warships.

When comparing these ratios to the late 16th-century designs of the Apostles, the main differences appear again in the depth of hold–to-breadth ratios as in the case of the previous sets of Ordinances. However, the length-to-breadth ratios are not that different from those of the final designs for the Apostles, which ranged between 3.12:1 for the large Apostles, 3.18:1 for the small ones, and 3.19:1 in the case of the medium-sized ones. Moreover, the ratios of the Barros designs as warships for the Apostles were even higher than those of the 1618 Ordinances at 3.35:1 and 3.41:1. It should be noted that the ratios in the 1618 Ordinances were intended for either merchantmen or warships. In fact, the 1618 hull ratios are more similar to those of Escalante and Palacio, and even to some of Illyrian galleons, than to the new 17th-century designs, or the second half of the 16th-century warships built by Menéndez and Barros.

Nuestra Señora del Juncal *(1622)*

The comparative analysis of *Nuestra Señora del Juncal* ratios, a galleon built as a merchant vessel, show a length-to-breadth ratio almost equal to the final design proposed for the small and medium-sized Apostles although slightly higher than those for the large ones, and those in César's designs, but much lower than Barros's warships designs. On the other hand, the depth of hold of *Nuestra Señora del Juncal* equaled half of its breadth as was customary during the beginning of the 17th century. In any case, this galleon had a shorter and wider hull than all three sets of Ordinances recommended, even for merchantmen. However, this did not prevent the galleon from serving as the *Capitana* of the Indies fleet when it was required, due to the Spanish Crown's chronic shortage of warships.

Martín de Arana construction of six galleons (1626-1627)

Interestingly, the initial design of the galleons to be built by Arana showed, despite their modifications, ratios very similar to those proposed in the 1618 Ordinances, although with slightly wider floors. However, the ratios of the vessels, once completed, became lower than intended. In fact, their length-to-breadth ratios resulted in lower figures than the final design for the Apostles. Only the depth of hold-to-breadth ratio differed from the Apostles design since it was slightly lower than half of the ships breadth. In any case, the final ratios for Arana's galleons were not that different from those recommended in the 1618 Ordinances for ships of similar breadths.

Dialogo entre un Vizcayno y un Montañés sobre la fábrica de navíos ***(ca. 1631-1632)***

The length-to-breadth ratios proposed in the shipbuilding manuscript *Dialogo entre un Vizcayno y un Montañés sobre la fábrica de navíos* differed the most from those of the Apostles, including Barros's warship designs. In fact, not even the designs of Menéndez's *galeoncetes* or the earlier series of Barros's galleons had such long and narrow hulls except for the smallest ones. In fact, the length-to-breadth ratio was even more extreme than those of the 1607 Ordinances. Additionally, these galleons had lower hulls in comparison to any previous designs, especially with respect to the Apostles and 16th-century designs in general. Only Cano's designs exceeded the length-to-breadth ratios of López de Soto, especially in the case of merchant vessels. It should be noted that Lopez's designs were proposed for warships that could be converted into merchantmen simply by adding some girdling to the sides of the vessel. As such, these designs justly corresponded to multipurpose vessels.

Arana's contract to build nine galleons (1632-1639)

The construction of new galleons during the second third of the 17th century, such as the new series of galleons built by Arana in 1632, reveals an increase in the length-to-breadth ratios in the manner recommended by López de Soto in his manuscript. In fact, the length-to-breadth ratios proposed for these galleons were even slightly higher than the ones proposed by Lopez de Soto, although they became lower, in some cases, after their construction. Nevertheless, their ratios exceeded the final hull proportions chosen for the Apostles, and only the galleons with the lowest ratios were similar to the warship designs that Barros recommended for the Apostles. In any case, the original ratio projected for Arana's galleons was higher than those in the previous series of warships built by Menéndez and Barros in the second half of the 16th century. On the other hand, the depth of hold-to-breadth ratios of Arana's galleons were within the standard range expected for the ships of the 17th century but lower than those of the 16th century.

Francisco Díaz Pimienta designs (1645-1650)

The length-to-breadth ratios of the vessels built during the second third of the 17th century remained higher than those resulting from 1618 Ordinances until the 1666 modifications. In the case of the galleons proposed by Pimienta in 1645, his ratios became closer to those given in López de Soto's manuscript and to Arana's designs than to either the 1618 Ordinances or the 1607 Ordinances, which proposed a length-to-beam ratio 3.45:1. Moreover, Pimienta's specifications still maintained a depth of hold that equaled half of the galleon's breadth. The next series of galleons proposed by Pimienta in 1650 only lowered minimally the length-to-breadth ratio of the galleons with respect to the previous ones, while maintaining the same depth of hold-to-breadth ratio. Finally, the modifications introduced by Grillo and Lomelin in 1664 to build another series of galleons only reduced the depth of hold-to-breadth ratio of the vessels.

Dimensions of various galleons (1650-1660)

The dimensions of several galleons with breadths similar to those of the small and medium-sized Apostles surveyed between 1650 and 1660 showed length-to-breadth ratios closer to the 1607 and 1613 Ordinances than to the 1618 Ordinances. The hulls of these galleons had lengthened with respect to the Apostles designs, but also became lower due to changes in the designs of the master frame and the introduction of the *joba*. Interestingly, the highest length-to-breadth ratios of these galleons were still lower than those in the warship designs of Menéndez and Barros during the second half of the 16th century. On the other hand, the galleons still had low hulls since their depths of hold equaled half of their breadth or even less.

The Ordinances of 1666

The length-to-breadth ratios proposed in this modification of the Ordinances of 1618 were similar to those previously observed in the ordinances of 1607 for vessels of similar breadths. In contrast, the recommended depth of hold-to-breadth ratios appeared for the first time in the warships designs of the 1613 Ordinances, and were maintained in the following set of Ordinances in 1618. In other words, these galleons had long and narrow hulls as it was recommended in the 1607 Ordinances, but lower drafts. These proportions differed greatly from those intended for the Apostles, especially in the case of the small galleons, and even with those in the Barros warship designs. However, these length-to-breadth ratios are comparable to Menéndez's *galeoncetes*, Barros's first series of galleons and, interestingly, to the ratios resulting from López de Soto's manuscript. Basically, the new ratios resulting from the Ordinances of 1666 were the same as those that had been already observed in several designs of the second third of the 17^{th} century. Therefore, the 1666 modification of the Ordinances simply sanctioned officially the set of dimensions and hull proportions that were being used to build galleons, instead of proposing any innovation in the 17^{th}-century naval design.

The Ordinances of 1679

The modifications in the Ordinances of 1679 not only extended the length of hull with respect to its breadth, but also increased slightly its depth. The resulting length-to-breadth ratio became closer to the warship designs of the second half of the 16th century, but somewhat differing from the design of the Apostles, which, in comparison, were shorter, wider, and deeper. Interestingly, the closest values to these ratio were those of the 1607 Ordinances, which were modified before they were ever applied.

It should be noted that the ratios of the 18-cubit and 19-cubit breadth ships built and surveyed in Spain after the 1666 modification were already similar to those introduced by the modification of 1679. Therefore, the modification issued in 1679 again seems to sanction the dimensions and proportions that were already in use and deviated from the 1618 Ordinances. However, this does not imply that all the vessels had the same exact ratios since surveys conducted a year later showed ships with similar length-to-breadth ratios and even those with lower ratios. In the same way, the depth of hold-to-breadth ratios were also lower than the ones specified in the 1679 Ordinances.

Arte de fabricar reales *(1688)*

The length-to-breadth ratio of Gaztañeta's *Nuestra Señora de la Concepción* presents many similarities with López de Soto's proposals and the Ordinances of 1607. This is the same ratio that Barros used to build the small galleons in Guarnizo between 1582 and 1583 according to the survey conducted before the departure of the Great Armada in 1588. Interestingly, this was also the same hull proportion that Pre Teodoro recommended in the mid-16th century for a galleon designed as warship. It appears, then, that this was the recommended ratio for warships for a period of 150 years, from the second half of the 16th century until the end of the 17th century. In the same way, the depth of hold of this galleon is still quite low as was the norm for vessels built in the second half of the 17th century.

Recopilación para la nueva fábrica de baxeles españoles *(1691)*

The length-to-breadth ratio that Garrote proposed in his manuscript was again almost identical to the average ratio that resulted from the 1607 Ordinances, and similar to the 1613 Ordinances, but lower than the designs proposed by Lopez de Soto and Gaztañeta. With respect to the Apostles, the only design that showed a comparable length-to-breadth ratio was Barros's designs for warships. Interestingly, the other group of 16th-century galleons designed specifically as warships, with similar ratios to Garrote's designs, were the small galleons of the previous series built by Barros in Guarnizo. Finally, Garrote's design had the lowest hulls with a comparable ratio to the design of the Apostles. In fact, Garrote's ratios were similar only to some of Lopez de Soto's designs or, interestingly, Pre Teodoro's dimensions for galleons designed as warships.

Galleons* San José *and* San Joaquín *(1698)

The length-to-breadth ratios of these galleons were very conservative in comparison to other contemporary vessels, and identical to those of the 1618

Ordinances. In fact, the length-to-breadth ratios were shorter than those Barros proposed for the warship designs of the Apostles in 1590, although slightly higher than in the final designs for the Apostles. In contrast, their depth of hold-to-breadth ratio was among the lowest for the ships of this period. Interestingly, the last galleons built in Spain at the end of the 17th century had length-to-breadth ratios similar to the designs that Palacio proposed for his multipurpose *nao*.

Conclusions

The comparative analysis of the hull ratios of the Twelve Apostles with the previous series of galleons designed and built specifically as warships during the second half of the 16th century reveals that the Apostles' hulls were shorter and wider, but not deeper. Their length-to-breadth ratios, however, were still higher than the expected traditional ratio of 3:1 defined by the 16th-century *as-dos-tres* rule. In fact, only the merchant designs proposed by Barros for the Apostles followed these proportions. The depth of hold-to-breadth ratio, on the other hand, was similar in all 16th-century designs for both merchant and naval vessels, including the Apostles, which had depth of holds that generally equaled 2/3 of their breadths. Therefore, the main differences between the designs of the Apostles and earlier warships built during the second half of the 16th century were limited to the length of their hulls with respect to their breadth. It should be noted that this was the argument that Barros employed to justify his criticism of the design of the Apostles when he claimed that the galleons had been designed as merchant vessels rather than warships.

On the other hand, the ratios of the warships built by Menéndez and Barros during the second half of the 16th century produced ships with deep drafts that constrained their performance as naval vessels. In fact, such long and narrow vessels with length-to-breadth ratios between 3.47:1 and 3.6:1 would not appear again until the second third of the 17th century, after years of testing different hull designs and proportions in which the depth of hold became less than half of the breadth to overcome the deep-draft problem.

In addition, despite the relatively conservative hull ratios of the Apostles with respect to those of the earlier warships of the 16th century, their hulls were still slimmer than the proportions of specialized merchant vessels such as the 24M vessel wrecked at Red Bay, the majority of the *naos* built on the northern coast of Spain, and even the supposedly Mediterranean-built oceangoing warships that took part in the Spanish Armada in 1588, or those of the Illyrian squadron. Moreover, the length-to-breadth ratios of the Apostles were closer to the multipurpose vessels described in contemporary Spanish treatises, such as those by Escalante and Palacio, than to previous warship designs or ships designed specifically as merchantmen.

In fact, ships built in Spain during the first quarter of the 17th century maintained similar length-to-breath ratios as those of the Apostles despite the different sets of shipbuilding Ordinances issued during the same period to regulate Spanish naval design, which advocated for higher ratios with longer and narrower hulls. Even the galleon designs proposed by the Portuguese Manuel Fernandes at the beginning of the 17th century showed length to breadth ratios similar to those proposed for the Apostles. The only noticeable difference between the ratios of the early 17th-century vessel and the Apostles, and earlier 16th-century warships, is in the depth of hold-to-breadth ratio that became half, or even less so, of the ship's breadth in an attempt to overcome the deep draft issues observed in earlier vessels. This reduction was probably related to the introduction of the *joba* in Spanish naval design, which increased the stability of the vessel, reducing its draft and need of ballast, while increasing the speed of the vessel.

It was not until the second half of the 17th century when the length-to-breadth ratios of vessels built in Spain regained similar values to the specialized warships of the second half of the 16th century. This tendency continued until the end of the 17th century, in parallel with new design methods introduced in the construction of ships in Spain. However, the 17th-century shipbuilding philosophy in Spain aimed for the design of multipurpose vessels that could serve both as specialized warships and/or cargo vessels depending on the circumstances. This new approach was more motivated by the constant need for both warships and merchantmen by the Spanish Crown from the second half of the 16th century onward than by any deliberate attempt to develop a new type of vessel.

Interestingly, the analysis of the dimensions of the ships surveyed during the second half of the 17th century shows that the later modifications of the shipbuilding ordinances issued in 1666 and 1679 seem to sanction the new hull ratios in use more than to introduce them. The major differences affected the length-to-breadth ratios, which were increased. The depth of hold-to-breadth ratio, on the other hand, still equaled half of the breadth or were even lowered during the same period. Ironically, the most common hull ratios used in Spain during the second half of the 17th century were the same that Pre Teodoro had already recommended in the mid-16th century for galleons designed as warships. Finally, it should be noted that the last galleons built in Spain at the end of the 17th century presented again lower length-to-breadth ratios as the ships built in the late 16th and early 17th centuries. However, these vessels had proportionally much lower hulls than in the earlier examples.

CHAPTER V

THE DESIGN OF THE MASTER FRAME OF SPANISH SHIPS BASED ON TREATISES BETWEEN 1575 AND 1691

During the 16th and 17th centuries ships were designed without detailed plans or ship's lines and, therefore, master shipwrights and carpenters only required a set of main dimensions to determine the shape and proportions of the hull of a ship. The final design of a vessel was normally determined by a series of specific proportions given between the main dimensions of the ship, such as the *as-dos-tres* (1:2:3), and the practical experience of the shipwright himself. After the shipwright decided on the main dimensions of a ship, the master frame was designed according to them. The curvature of the midship section was responsible for the shape of the hull which, in turn, determined the draft of the ship and its ballast requirements.[1] The master frame shape was then projected forward and aft to the tailframes using a series of geometrical methods which modified the rising and narrowing of the floors, and the arcs of the futtocks.[2] Different methods to define the shape of the master frame were developed in the Mediterranean and northwestern Europe during the 16th century. In Venice, the midship section of a vessel was determined using breadth measurements at different heights, while mathematical formulas were used in England to define various arcs that

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[1] Gaztañeta et al. 1992, 1:16.
[2] Steffy 1994, 97-8.

defined the master frame (Figure 25).[3] In any case, both systems could have been derived from design methods originated in the eastern Mediterranean.[4] Written evidence supports the theory that the master frames of Iberian ships were defined using a single arc instead of several of them in sequence, as it appears in 15th- and 16th-century Mediterranean and English manuscripts.[5] Nevertheless, the aim of all these design methods was to create a series of reference points that defined the arcs used in determining the shape of the master frame.

The design of the master frame in Spain

One of the main difficulties when attempting to reconstruct the master frame of a 16th- or 17th-century Spanish ship is the absence of information about the method employed to determine its shape. Information about the design of the master frame in Spanish written sources, including shipbuilding treatises, manuscripts, and archival documents, is both limited and characterized by the paucity of graphical representations. These texts consist mainly of lengthy discussions about the ideal dimensions and proportions of ships instead of describing actual construction methods.

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3 Steffy 1994, 128-29.

4 Steffy 1994, 128; Loewen 2007, 3:3.

5 Castro (2008, 78-9) proposed the use of a single arc to define the midship section of ships as a distinctive characteristic of Iberian vessels. He added this characteristic to the list of 11 traits that Oertling (2004) proposed to define the Iberian shipbuilding tradition. However, the only evidence provided to support this hypothesis is a drawing of the midship section represented in Oliveira's treatise without further information or arguments to support his theory.

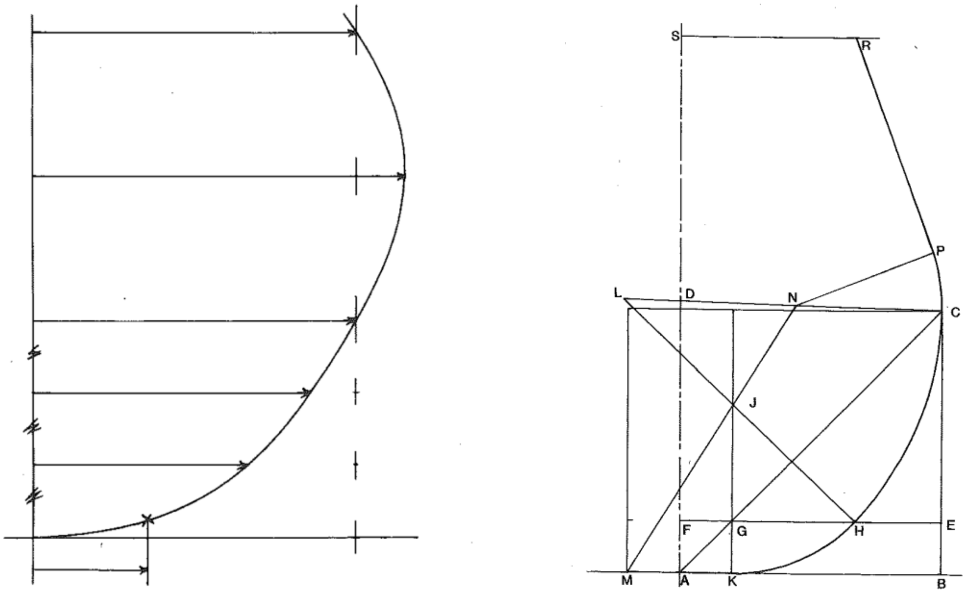

Figure 25. Venetian (left) (after Steffy 1994, 129, figure 5-1), and English (right) midship design methods (after Steffy 1994, 145 figure 5-20).

The *Instrucción Naútica* of García de Palacio (1587) is the only 16th-century Spanish shipbuilding treatise that provides graphical representations of the master frames and tailframes of two different vessels, including a brief description of the method employed to determine one of them.[6] Gregorio Sarmiento also provides an illustration of the master frame of a galleass in 1589.[7] However, the next sets of illustrations representing the design of the master frame only appear in the last quarter of the 17th-century, almost a century after Palacio and Sarmiento's depictions. These graphical representations of master frames appear in a series of archival documents

[6] Palacio 1994, fols. 92v, 93v-94, 96-97.
[7] AGS MPD, 16, 165.

located in the Archive of Indies,[8] and the shipbuilding manuscripts of Gaztañeta's *Arte de Fabricar Reales* (1688) and Garrote's *Nueva Fábrica de Bajeles* (1691).[9] None of the other shipbuilding treatises and manuscripts written in Spain between the second half of the 16th century and the late 17th century include any representation or detailed explanation about how to determine the master frame of a ship. Only the 1618 shipbuilding Ordinances (*Ordenanzas*), issued by the Spanish Crown to regulate the design and tonnages of both merchant and naval vessels, included a reference to the type of arc used in the design of the master frame.[10]

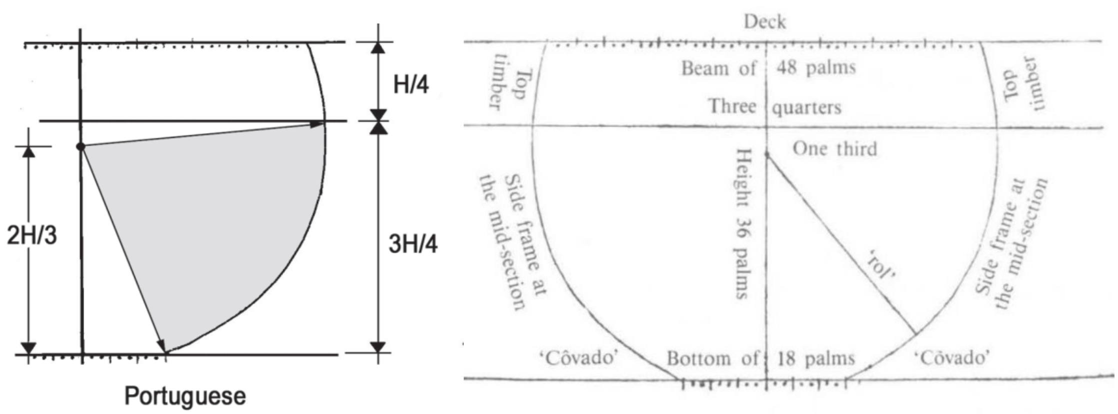

Figure 26. Portuguese midship section after Oliveira (left) (after Castro 2008, 79, figure 4), and Oliveira's midship section (right) (after Oliveira 1991, 87, figure not numbered)

In contrast, the late 16th-and early 17th-century Portuguese shipbuilding treatises and manuscripts offer several descriptions and graphical representations of the methods

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[8] AGI MP 13E, AGI MP 10 (1685), AGI MP 11 (1685), AGI MP 15 (1696), in Hormaechea et al. 2012, 1: 227-28, 230; also in Moya 1981, 155.
[9] Gaztañeta et al. 1992, 2:55, fol. 63; Garrote (1691) in Artíñano y de Galdácano, 1920, 122.
[10] Boix 1841, 4:25.

used to determine the midship sections in Portugal. Oliveira's *Livro da fávrica das Naos* (1580) explains how to design the master frame of a 600-ton *nau*, and includes a graphical representation.[11] In Oliveira's method, the master frame is generated with a single circle extending up to ¾ of the total height of the hull (Figure 26). In fact, Castro's hypothesis about the use of a single arc to define the midship section of Iberian vessels is based on Oliveira's method (Figure 26).[12] Despite the similarities, however, Oliveira's method presents several differences with contemporary Spanish design methods and even with those of other Portuguese authors. For instance, Lavanha's *Livro primeiro da architectura naval* (ca. 1606-1618) also provides high quality representations and descriptions about the design method of a four-decked *nau*'s master frame.[13] However, Lavanha's master frame is a composite of several arcs instead of a single one (Figure 27).[14]

Manuel Fernandes's *Livro de traças de Carpinteria* (1616), on the other hand, includes several illustrations and descriptions on how to determine the master frame of several ship types such as a four-decked *nau*, galleons of different tonnages, a *pataxe*, a *galizabra*, and even a galley.[15] However, many of the illustrations are not accurate, and seems that other were drawn using a mold.[16] Fernandes provides two different methods to determine the midship sections of the four-decked *nau*.[17] According to Pimentel, the

[11] Oliveira 1991, 185-87.
[12] Castro 2008, 78-9. Figure 4.
[13] Lavanha and Barker 1996, 36-8.
[14] Lavanha and Barker 1996, 85-9; Hormaechea et al. 2012, 2:213-16.
[15] Fernandes 1989.
[16] Visiers 2015, 169.
[17] Fernandes 1989, fols. 71, 83.

first of these methods (Type 1) is also based on a circle although it differs from that of Oliveira. In this case, the frame is generated by a circle having a radius equal to half-breadth of the ship (Figure 28). This method resembles the traditional design method used in Spain during the 17th-century according to Gaztañeta and Garrote.

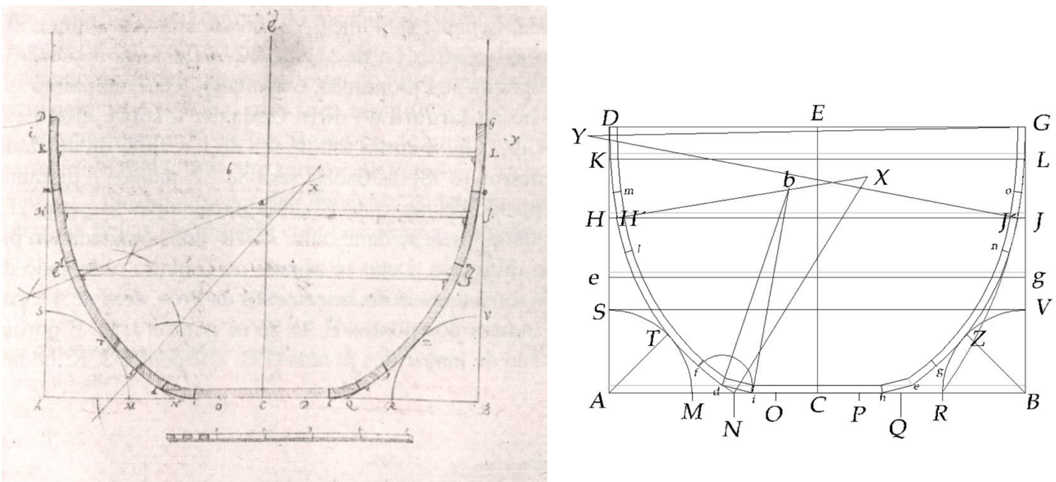

Figure 27. Lavanha's midship section (right) (after Lavanha and Barker 1996, 36, figure 2), and design interpretation (left) (after Hormaechea et al. 2012, 2:214, figure not numbered).

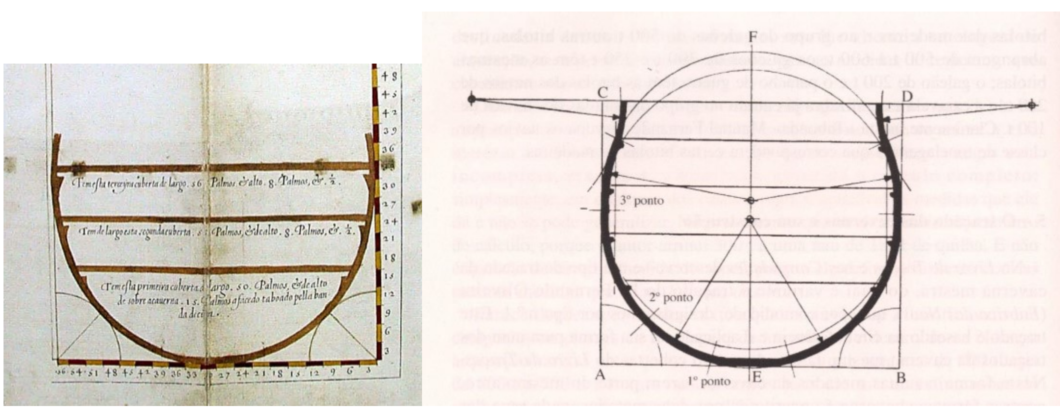

Figure 28. Four-decked *nau* Type 1 midship section (left) (after Fernandes 1989, fol. 71, figure not numbered) and Pimentel Barata interpretation (right) (after Lavanha and Barker 1996, 86, figure 2).

The second design (Type 2), provided for the four-decked *nau* is based on a vertical oval defined by three arcs (Figure 29**)**. However, Lavanha does not explain how to determine the ratios between the breadth and depth of hold to define the midship section. In addition, Fernandes provides yet another method to determine the shape of the Type 2 master frame that does not appear in other contemporary treatises until the 18th century. This method consists of a series of five offset measurements taken at equal intervals along the vertical axis that defines the ship's breadth (Figure 29).[18]

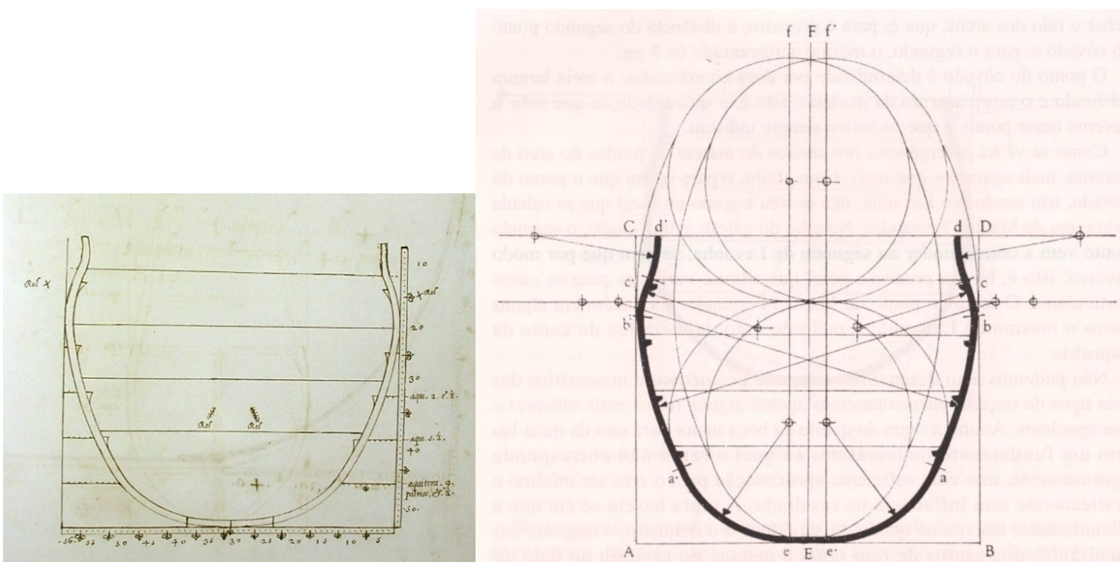

Figure 29. Four-decked *nau* with Type 2 midship section generated with three arcs or five offsets (left) (after Fernandes 1989, fol. 83, figure not numbered) and Pimentel Barata interpretation (right) (after Lavanha and Barker 1996, 88, figure 3).

In addition to the Spanish shipbuilding treatises and manuscripts, there are also several archival documents related to the designs and technical characteristics of vessels

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[18] Lavanha and Barker 1996, 87-9, 206-8.

built for the Spanish Crown during the second half of the 16th century and the 17th century. Unfortunately, the majority of these documents only provide the main dimensions used by the shipwrights to define the master frames of the vessels. These dimensions consisted of the ship's breadth, the depth of hold, and the height for the ship's maximum width, which equaled the ship's official breadth, and the tumblehome. It is noteworthy that the floor length, one of the main dimensions used in defining the shape of the master frame, was not included in the 16th-century design reports. Nevertheless, shipwrights were able to design the ship's master frame with this basic set of measurements which, in turn, was responsible for the change and development of the shape of the hull over time.

Finally, archaeological evidence is another source of information related to the design of Spanish oceangoing vessels, including galleons, although still limited in comparison to vessels of other nations. A Spanish version of *Mary Rose* or *Vasa* with a high level of preservation above the ship's waterline to allow study of the design of the master frame has yet to be found. Only the 16th-century 24M wreck excavated in Red Bay (Canada) and, to a lesser extent, the Western Ledge Reef wreck (Bermuda) have provided enough archaeological evidence to produce hypotheses about the methods employed to design midship sections. However, those hypotheses are largely based on the design methods employed in northwestern Europe rather than the models suggested in the Spanish treatises and manuscripts.

In any case, analyses of written sources and archaeological evidence reveal that the design of midship sections of 16th- and 17th-century Spanish vessels was based on the use of a single arc. Either side of the master frame was defined by a single arc from the point marking the turn of the bilge (*puntos de escoa*) to the level at which the ship's breadth was measured. The arc that defined either side of the master frame could also be viewed as a part of a single circle whose center was located along the central axis of the master frame or could have two centers, one for each arc, both on the level of the maximum breadth but on either side of the ship's central vertical axis. The shape of the master frame above the ship's breadth was then defined by the tumblehome, measured at the level of the upper deck or at the upper end of the top timbers. This design method combined a reduced set of vertical and horizontal measurements, which included the ship's maximum breadth, the vertical height at which the ship's maximum breadth was situated from the flat of the main floor, the floor length, and the tumblehome measured at the top of the top timber or the upper deck. Moreover, at the beginning of the 17th century, two more dimensions were added to this set of Spanish shipbuilding measurements, the rising (*astilla muerte*) of the flat of the master frame and the *joba*, which determined the outward tilting of the futtocks forward and aft of the master frame.

Spanish shipbuilding manuscripts, treatises, and ordinances

A series of shipbuilding treatises and manuscripts were written in Spain and Spanish territories in the New World during the last quarter of the 16th century and beginning of the 17th century. Not all these works were published at the time they were written, although all the original manuscripts have been either partially or completely published since the 19th century. Additionally, during the early 17th century three sets of shipbuilding ordinances, including two later modifications, were issued by the Spanish Crown in order to regulate the design and tonnages of both merchant and naval vessels used on the Indies run. All these works provide important information about the development of ship design in Spain.

Itinerario de Navegación de los mares y tierras occidentales *(1575)*

Escalante de Mendoza wrote his treatise in 1575, but the Indies Council never authorized its publication due to the sensitive information it provided about the navigation routes and sailing dates of the Indies fleets.[19] The treatise included a section dedicated to shipbuilding in which Escalante described the ideal dimensions and tonnages, rigging, and outfitting of the vessels built for the Indies run.[20] He provided all ship dimensions in cubits (*codos*) although without specifying the specific type of cubit he used. It is reasonable to believe that he meant Castilian cubits (*codos castellanos*), which were the typical linear unit used in the Andalusian Atlantic, since he also mentioned the tons (*toneladas*) used in Seville for the volumes of the ships. [21]

Escalante included in his manuscript the ideal proportions between the main dimensions of the vessels, such as the maximum breadth and depth of hold, and, more

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[19] Escalante 1985, 13.
[20] Escalante 1985, 39-46.
[21] According to Casado Soto (1988, 67), the Castilian cubit equaled 2/3 of a Castilian yard (*vara castellana*) or 32 fingers (*dedos*) (0.558 m), while the shipyard cubit (*codo de ribera*) equaled 2/3 of a Castilian yard plus 1 finger, or 33 fingers (0.575 m). Escalante (1585, 42) indicated a ton equaled two casks (*pipas*) of wine or water of 27.5 *arrobas* each, similar to the ones made in the *Carretería* suburb (*arrabal*) of Seville. Moreover, twelve of these tons (*toneladas*) were equal to 10 casks (*toneles*) of Biscay, after which the *toneladas* were named.

importantly, he described the resulting shape of the master frame.[22] In order to build a seaworthy vessel, both the ship's breadth and length of keel must be proportional to each other with a keel-to-breadth ratio of 2.27:1. On the other hand, the "true" depth of hold (*puntal*) of a ship was the height of the main deck or first fixed deck (*primera cubierta fija*) measured vertically along the mast down to the ship's floor, which is located on the upper surface (*al ras*) of the keel. The ship's depth of hold also had to be proportional to the length of the keel and breadth, but specially to the height of the entries and runs, although Escalante only indicated the run-to-depth of hold proportion, which was 0.5 (2.5/5):1 (Table 33). If these dimensions and proportions were applied correctly, the side of the hull should become round.[23] However, Escalante did not explain how to obtain the round shape or even if the sides of the vessel were formed with a single or multiple arcs.

Table 33. Spanish shipbuilding treatises and manuscripts (1575-1587). Units given in Castilian cubits (1 cubit = 0.558m).

Source	**Tonnage** (*Toneladas*)	**Breadth** Cubits	**Floor (Deadrise)** Cubits	**Unplanked beams (height)** Cubits	**Main deck (Depth of hold)** Cubits	**Maximum breadth (height)** Cubits	**Upper deck (height)** Cubits
Escalante 1575	400	2.2:5.5 B/K	-	-	-	-	
Palacio 1587	400	16 (K/2)	5.33 (B/3)	4.5	7.5	-	11.5

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[22] Escalante 1985, 39.
[23] Escalante 1985, 40.

Instrucción náutica para navegar *(1587)*

In his shipbuilding treatise, García de Palacio provided more detailed information related to the ideal design of a 400-ton (*toneladas*) *nao* that could serve as either warship or merchantman in the Atlantic and Pacific Oceans.[24] Palacio listed the main dimensions of the *nao*, which included the keel length (*quilla*), depth of hold (*puntal*), and the maximum breadth (*manga*), and the proportions between the main dimensions of the vessel (Table 33).[25] The linear and volume units of the *nao* were expressed in Castilian cubits (*codos castellanos*) and tons (*toneladas*).[26]

The official breadth of the *nao* was almost equal to half of its keel or 34 cubits. On the other hand, the depth of hold was measured from the top of the keel to the upper deck (*cubierta principal* or *puente*). The deck configuration of the *nao* included a row of unplanked beams at a height of 4.5 cubits, and the first deck (*primera cubierta*) at 7.5 cubits. According to Palacio, the upper deck (*puente*) was located at a height of 11 cubits, although in another section he mentioned a height of 11.5 cubits. Moreover, if a grating (*jareta*) was added on top of the upper deck, the total height of the vessel became 14.5 cubits.[27] Finally, Palacio indicated the length of the ship's floor (*plan*), which was 5.33 cubits or 1/3 of the ship's maximum breadth (Table 33).[28]

[24] Palacio 1944, 91v.
[25] Palacio 1944, 89 – 90v.
[26] Palacio 1944, 89v-90; According to Palacio (1944, 93v-94), the cubit (*codo*) equals 2 feet (*pies*) or 2/3 of a yard (*vara*) (0.558 m), and one ton (*tonelada*) equals two casks (*pipas*).
[27] Palacio 1944, 90-90v, 92.
[28] Palacio 1944, 92v.

Palacio, unlike Escalante, did provide an explanation, although incomplete, about how to design the *nao*'s master frame. Moreover, the treatise included graphical representations of the master and tail frames of a 400-ton *nao* and also for a 150-ton vessel, as well as longitudinal sections and top views of both vessels.[29] These graphical representations, despite inaccuracies in their scales and proportions, are still extremely valuable in understanding the method used for the design of the master frame.

In his treatise, Palacio indicated that the side of the midship section of the *nao* was defined by half a circle composed of three futtocks (one *estemanera* and two *barraganetes*) that extended from the ship's floor (*plan*).[30] Therefore, the radius of the half circle was located at the same height at which the ship's maximum breadth of 16 cubits was measured. Unfortunately, Palacio did not indicate the height at which the ship's breadth was situated. Yet, Palacio's illustration of the *nao*'s master frame appears to locate the ship's breadth at the level of the upper deck as in the design of a 600-ton *nau* described by the Portuguese Oliveira in 1580.[31]

However, the examination of the illustration of the master frame included in the treatise reveals that the midship section of the hull was generated using a single semi-circle whose center was located along the ship's central axis (Figure 30). In other words, both sides of the master frame were defined by a single circle, having a maximum diameter of 16 cubits, which was equal to the *nao*'s breadth. These arcs extended from

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[29] Palacio 1944, 93v-94 and 96-97.
[30] Palacio 1944, 92v.
[31] Palacio 1944, fol. 94; Oliveira 1991, 107.

the ends of the ship's flat floor, without deadrise (*astilla muerta*) up to the level where the ship's maximum breadth was measured. The graphical reconstruction of the *nao*'s master frame using a single circle and the dimensions listed in the treatise seems to confirm this hypothesis (Figure 31).

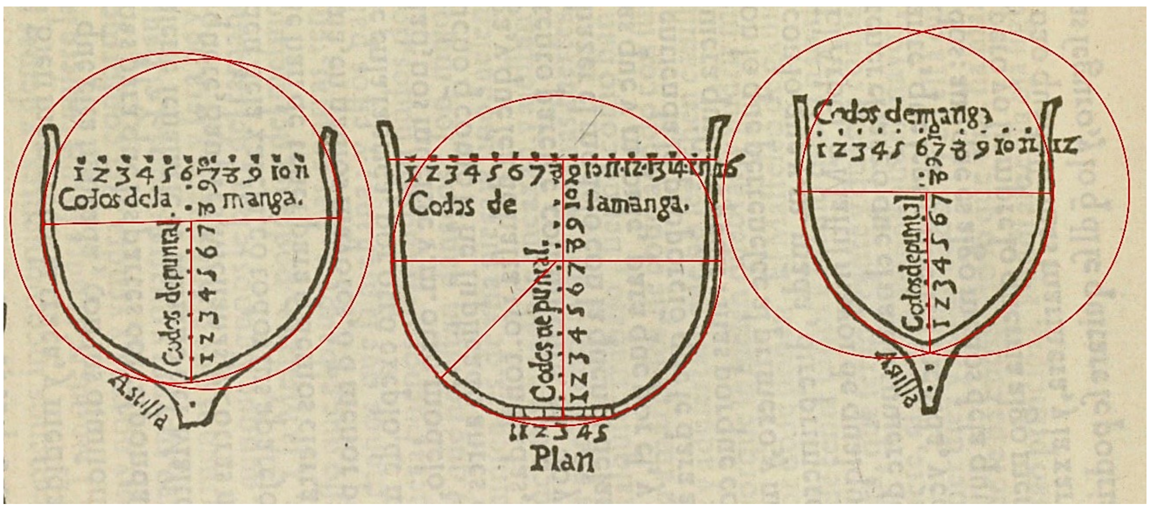

Figure 30. 400-ton *nao* midship section and tail frames (modified from Palacio 1944, fol. 94, figure not numbered).

If a single circle with an eight-cubit radius is used to define the *nao*'s master frame, its center will be located at a height of 7.5 cubits, the same height that Palacio gives for the beams that support the *nao*'s main deck.[32] It should be noted that the arcs used to define the *nao*'s tailframes have the same radius as the ones used in the master frame, but with their centers at different positions (Figure 30). Moreover, Palacio

[32] Rubio Serrano 1991; Rieth 1988, Visiers 2015.

specifies in his treatise narrowing values for the breadth and also of the tail frames of his vessel.[33]

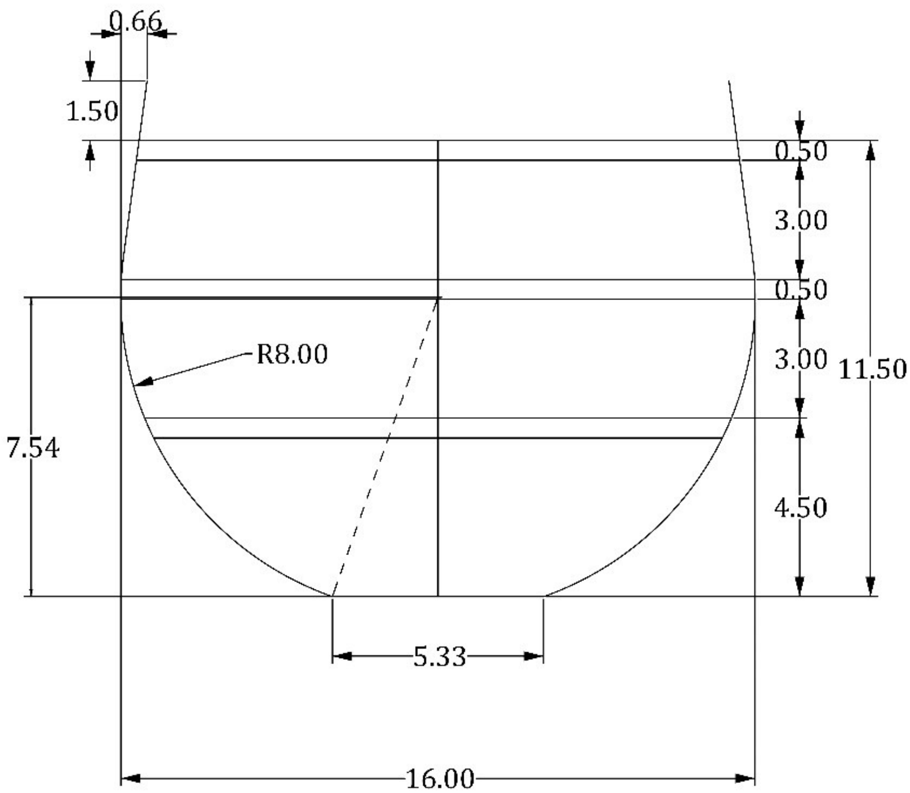

Figure 31. Graphical representation of the midship section of Palacio's 400-ton *nao*. Units given in Castilian cubits (1 cubit = 0.558 m) (drawing by J. Casabán).

The illustration of the master frame of the 150-ton vessel shows that its sides were also defined using a single circle with its center located along the central axis of the frame (Figure 32). In this case, the ship's maximum breadth is located between the main

[33] Palacio 1944, fol. 92v.

and the upper decks, as occurs in the final designs for the Twelve Apostles, and the tailframes are also defined by the same arc used for the breadth of the master frame.[34] However, the dimensions that appear in his illustrations do not allow for the generation of the master frame using a single circle, as in the case of the 400-ton *nao*. Moreover, Palacio does not provide any information about the 150-ton vessel in the treatise, which makes it difficult to determine the real dimensions of the ship. Nor does Palacio's treatise provide any information about the master frame's tumblehome for the 400-ton *nao*. In fact, the illustration of the *nao*'s master frame shows how its sides as extending vertically from the ship's maximum breadth to the top of the bulwarks (Figure 30).

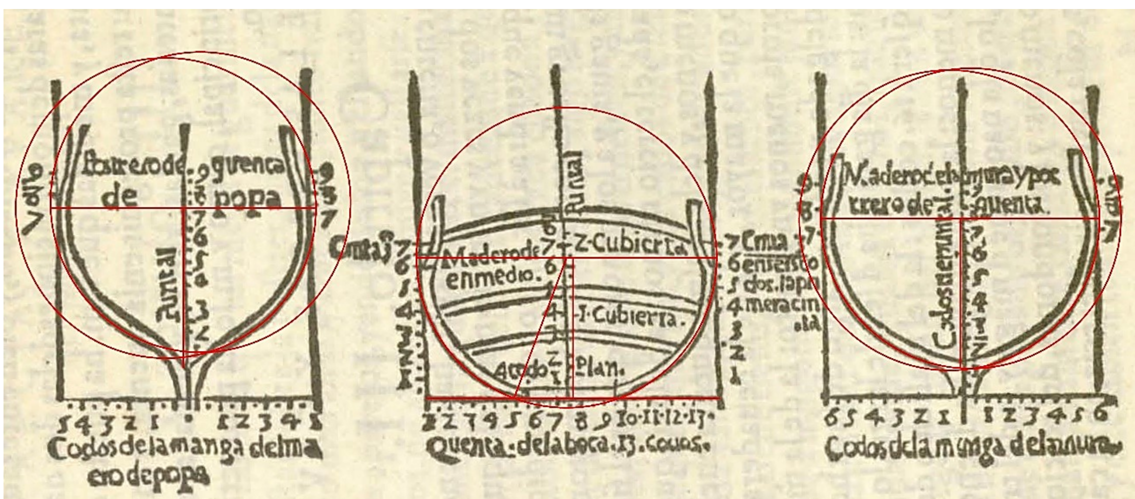

Figure 32. 150-ton vessel midship section and tailframes (modified from Palacio 1944, fol. 97, figure not numbered).

[34] AGS GYM Leg. 245 doc. 11.

On the other hand, the representations of the master and tailframes of the 150-ton vessel show a tumblehome of about one cubit on either side with respect to the ships maximum breadth (Figure 32). In any case, there is no explanation in the text on how to define and generate the tumblehome of any of the vessels. The design of a ship's tumblehome was probably decided during construction, and depended on the expertise of the shipwright. Therefore, a tumblehome of 0.66 cubits was used in the graphical reconstruction presented in this study for the midship section of Palacio's 400-ton *nao* (Figure 31). This was the same value recommended for the tumblehome of the small Apostle that had a breadth of 15 cubits, only one cubit wider than Palacio's *nao*.

Despite the similarities between Palacio's and Oliveira's methods of defining the shape of a ship's master frame, there are also important differences between them. Both authors define midship section using a single circle that connects the ends of the floor timber, or turn of the bilge, with the ship's maximum breadth, and whose center is located along the central axis of the master frame. However, the main difference between Palacio and Oliveira's methods are related to the derivation and location of the ship's maximum breadth, which, in turn, determines the radius of the circle with which the master frame is defined. According to Oliveira, the center of the circle is located 1/3 of the total ship's height below the upper deck. Therefore, the radius of the circle is equal to the distance measured from the center of the circle to the end of the ship's floor which is slightly longer than the ship's half breadth. Moreover, the circle, which also defines the sides of the master frame, runs not only up to the height of the ship's maximum width but it continues up to ¾ of the total height of the vessel. The sides of the frame then straighten and turn inwards until reaching the upper deck level whose breadth equals to the ship's official breadth.[35] Thus, the main difference between Oliveira's and Palacio's midship section is in the definition of "maximum breadth", which in Oliveira's case refers to the upper deck breadth or "official", below which is situated the ship's actual maximum breadth. In Palacio's definition, however, the ship's "breadth" corresponds to its actual maximum breadth. In either case, the maximum breadth of both designs are situated below the upper deck.

Finally, there are also similarities between the methods that Palacio proposes to define the master frame and Escalante's reference to its shape. Both authors locate the ship's breadth and depth of hold at the level of the main deck in order to generate a rounded sides. Moreover, Palacio clearly indicates that the sides of the master frame are defined with a half circle, which results in a round shape, a feature that is also confirmed by the illustrations provided in his treatise. It seems, therefore, there is a specific pattern for the shape of the master frame in Spanish shipbuilding by at least the last quarter of the 16th century.

The master frame of a galleass (1589)

Gregorio Sarmiento provided in 1589 another example of the design of a master frame based on a single circle. His depiction of a master frame shows the midship section of a galleass (*galeaza*) with three decks, with a grating in the upper deck (Figure

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[35] Oliveira 1991, 185-86.

33).[36] Although the drawing does not include the units or the dimensions he provided, unlike with Palacio or Oliveira, it is still possible to determine the method employed in its design.

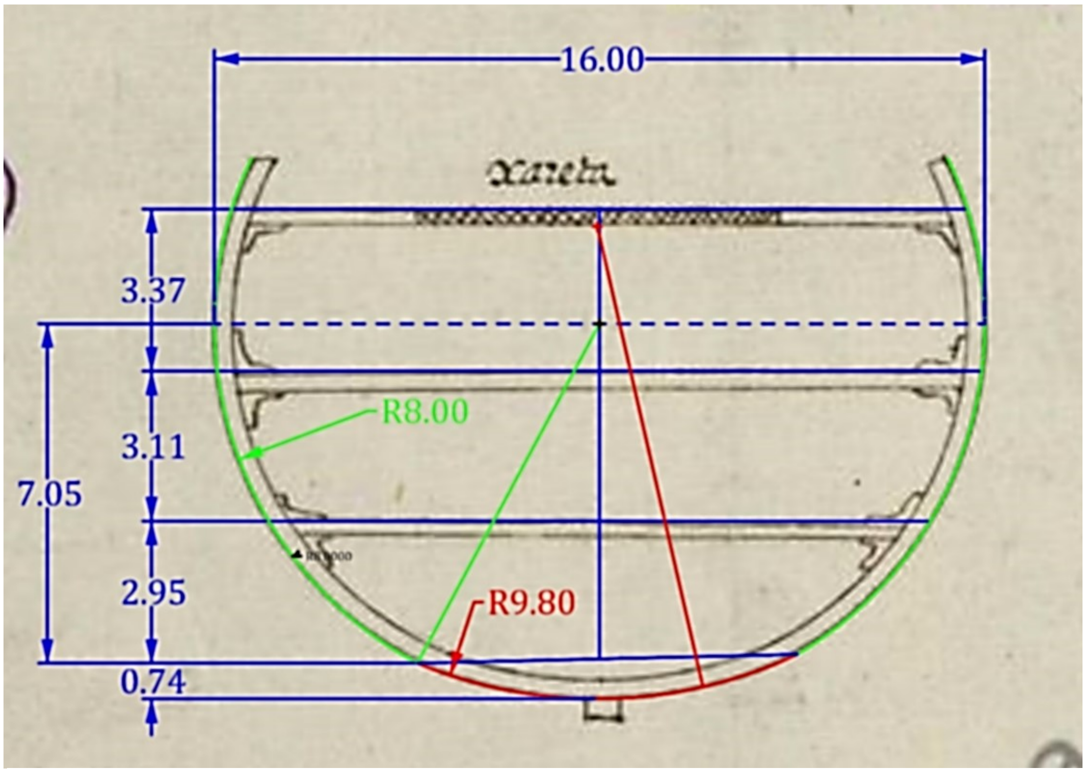

Figure 33. Midship section of Sarmiento's galleass (modified from AGS, MD 16, 165).

In this case, both sides of the master frame are again defined with a single circle, as with those of Palacio's and Oliveira's midship frames, thus producing a round shape as Escalante mentioned in his treatise. The center of the circle is located along the central axis of the master frame, slightly above the main deck as in other contemporary

[36] AGS MPD, 16, 165.

designs, such as the final design of the committee of the shipwrights for the Apostles.[37] The radius of the circumference that defines the sides of the frame is equal to half of the ship's maximum breadth, and joins the center of the circle with either end of the ship's floor that, here, is curved instead of flat, as in Palacio and Oliveira's examples. However, the arc of the floor differs from the circle that defines the sides of the master frame. In any case, the depth of hold-to-breadth ratio of this section is only 0.46:1, similar to Palacio's ratios for the 400-ton *nao*, while the ratio of floor-to-breadth is 0.49:1, closer to the 17th-century ratios than to the typical 1/3 observed in designs of the second half of the 16th century, such as Palacio's 400-ton *nao* or even in the designs of the Twelve Apostles.

The Ordinances of 1607

The first set of shipbuilding Ordinances (*Ordenanzas de construcción*) that regulated the design of warships and merchant vessels for the Armada of the Ocean Sea (*Armada del Mar Oceáno*) and the Indies run (*Carrera de Indias*) were issued in Spain in 1607. These Ordinances classified vessels as ships (*navíos*), small galleons (*galeoncetes*), and galleons (*galleons*) depending on their tonnages and breadths, and none had more than two decks (Table 34).[38]

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[37] AGS GYM Leg. 245 doc. 11.
[38] Navarrete 1971, 23, doc. 47, 288-297, in Rodríguez 2008, 90-123.

Table 34. Ordinances of 1607.

Type of vessel	**Tonnage** (*toneladas*)	**Breadth** Cubits	**Floor (Deadrise)** Cubits	**Unplanked beams** Cubits	**Orlop deck** Cubits	**Main deck (Depth of hold)** Cubits	**Maximum breadth (height)** Cubits	**Upper deck** Cubits	**Tumblehome** Cubits
Ship (*navío*)	150 1/2	10	M/2 (-)	Scarfs between 1st and 2nd futtocks	-	5.5	5.5	-	-
Ship (*navío*)	178 6/8	11	M/2 (-)	Scarfs between 1st and 2nd futtocks	-	6	6	-	-
Ship (*navío*)	238 2/8	12	M/2 (-)	Scarfs between 1st and 2nd futtocks	-	6.5	6.5	-	-
Small galleon (*galeoncete*)	297 5/8	13	M/2 (-)	Scarfs between 1st and 2nd futtocks	-	7	7	-	-
Small galleon (*galeoncete*)	373 3/8	14	M/2 (-)	Scarfs between 1st and 2nd futtocks	-	7.5	7.5	-	-
Galleon (*galeón*)	487 1/8	15	M/2 (-)	Scarfs between 1st and 2nd futtocks	-	8	8	11	-
Galleon (*galeón*)	567 7/8	16	M/2 (-)	Scarfs between 1st and 2nd futtocks	-	8.75	8.75	11.75	-
Galleon (*galeón*)	669 3/8	17	M/2 (-)	Scarfs between 1st and 2nd futtocks	-	9.25	9.25	12.25	-
Galleon (*galeón*)	755	18	M/2 (-)	Scarfs between 1st and 2nd futtocks	-	9.5	9.5	12.5	-
Galleon (*galeón*)	897 3/8	19	M/2 (-)	Scarfs between 1st and 2nd futtocks	-	10	10	13	-
Galleon (*galeón*)	1033	20	M/2 (-)	Scarfs between 1st and 2nd futtocks	-	10.5	10.5	13.5	-
Galleon (*galeón*)	1184 5/8	21	M/2 (-)	Scarfs between 1st and 2nd futtocks	-	11	11	12	-
Galleon (*galeón*)	1351 5/8	22	M/2 (-)	Scarfs between 1st and 2nd futtocks	-	11.5	11.5	14.5	-

The Ordinances listed the main dimensions for each ship type, including the length (*eslora*), depth of hold (*puntal*), height for the ship's maximum breadth (*lo mas* *ancho*), keel length (*quilla*), and height between the main and upper decks (*puente*) for two-deckers. All the dimensions were provided in royal cubits (*codo real*), which was the same as the shipyard cubit (*codo de ribera*).[39] This type of cubit had become the standard linear unit for shipbuilding and for surveying Spanish vessels in 1590 by a decree of Philip II. The decree intended to prevent any abuse and confusion in the dimensions and tonnages of the vessels.[40]

The Ordinances also provided guidelines about how to build ships and their scantlings, although they did not include any explanation or illustration describing the method to define the shape of the master frame.[41] The depth of hold of the master frame was to be measured from the ceiling planking (*granel*) to the top the main deck.[42] The main floor timber had to be as wide as possible, at least half of the maximum breadth to ensure the shallowest draft, and there were no references to the rising (*astilla muerta*) of the main floor.[43] There was no mention either to the height at which the row of unplanked beams was situated, although they had to be located between the main floor timber and the main deck at the level of the scarfs between the first and second futtocks.[44]

According to the Ordinances, the maximum breadth of the ship had to correspond to the ship's official breadth, which was located at the same height as the main deck,

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[39] Navarrete 1971, 23, doc. 47, 288-297, in Rodríguez 2008, 99-100.
[40] Casado Soto 1988, 58-71.
[41] Navarrete 1971, 23, doc. 47, 288-297, in Rodríguez 2008, 94-9.
[42] Navarrete 1971, 23, doc. 47, 288-297, in Rodríguez 2008, 99.
[43] Navarrete 1971, 23, doc. 47, 288-297, in Rodríguez 2008,97.
[44] Navarrete 1971, 23, doc. 47, 288-297, in Rodríguez 2008, 94-5.

whether the vessel was designed as a warship or merchant vessel.[45] For instance, a galleon with a breadth of 16 cubits had the maximum breadth located at the main deck level or at depth of hold of 8.75 cubits, with the upper deck situated 3 cubits above the main deck. However, there was no mention of a tumblehome on the master frame (Figure 34). This limited set of dimensions does not allow the defining of the galleon's master frame with a single circle, as in the case of Palacio's 400-ton *nao* and Sarmiento's galleass. Instead, two arcs with the same radius but different origins are necessary to define the sides of the master frame, one arc for either side. The centers of both arcs are located at the level of the main deck, where the ship's maximum breadth is measured, but moved 1.5 cubits to either side of the master frame's central axis (Figure 34). Only in this manner is it possible to use a single arc to define either side of the master frame, although the radius of these arcs will always be longer than half of the ship's maximum breadth, unlike Palacio's and Sarmiento's midship sections. This will be the only way to define the master frame of any vessel according to the dimensions provided by each set or Ordinances issued during the 17th century.

It should be noted, however, that the Ordinances of 1607 were never implemented due to the complaints of the House of Trade (*Casa de Contratación*), representing ship owners and builders.[46] Consequently, a new set of ordinances was

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[45] Navarrete 1971, 23, doc. 47, 288-297, in Rodríguez 2008, 99.
[46] Phillips 1994, 94.

developed by Juan de Veas and other naval experts, and issued in 1613 to correct the deficiencies observed in the previous set.[47]

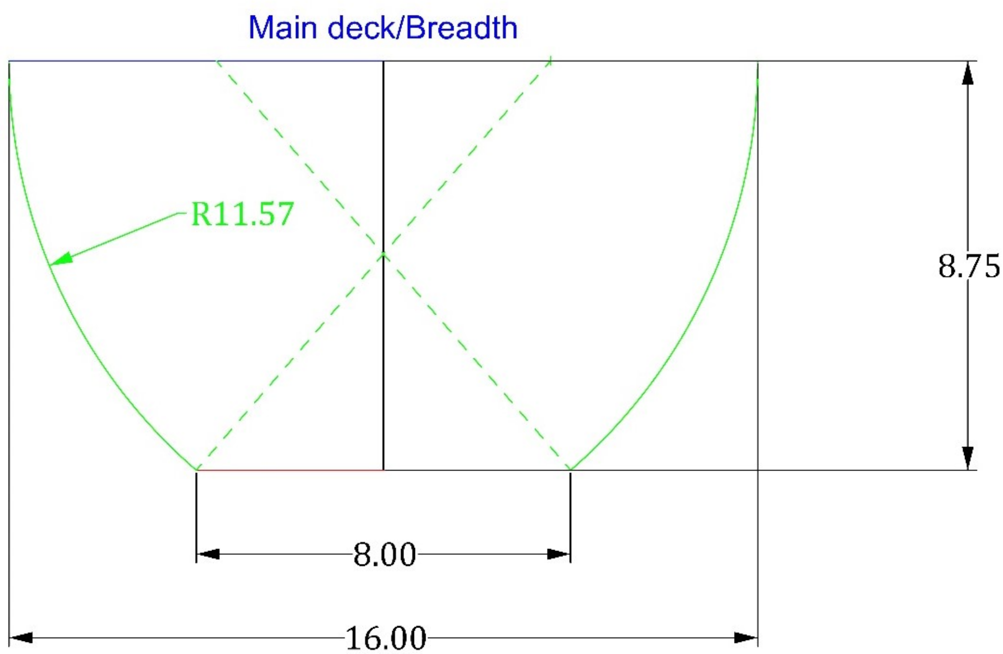

Figure 34. The master frame based on Ordinances of 1607. Units in cubits (1 cubit = 0.575 m) (drawing J. Casabán).

Arte para fabricar y aparejar naos *(1611)*

The Captain Thomé Cano published his shipbuilding treatise *Arte para fabrica y aparejar naos* in 1611. This treatise anticipated some of the modifications that would be introduced in the new set of Ordinances of 1613, such as the increase of keel length and rakes with respect to breadth.[48] His treatise was divided into four sections or "*Diálogos*"

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[47] Goodman 1997, 117.
[48] Cano and Dorta 1964, 24.

(Dialogues), and the ideal designs of a 12-cubit breadth *nao*, one as warship and the other as merchantman, were described in section two. As in the case of Escalante's work, or the Ordinances of 1607, Cano did not include any graphical representation of his designs. He did list, however, the main dimensions for both designs in which all of the main measurements were calculated from the ship's maximum breadth (Table 35).[49] All linear measurements were expressed in Castilian cubits, and the volumes in tons as in Palacio's and Escalante's works.[50] After discussing the flaws he observed in the ships built in Spain until that time, he proposed his own designs.

Table 35. Cano's treatise (1611).

Type of vessel	**Tonnage** (*Toneladas*)	**Breadth** Cubits	**Floor (Deadrise)** Cubits	**Unplanked beams (height)** Cubits	**Main deck (Depth of hold)** Cubits	**Maximum breadth (height)** Cubits	**Upper deck** (height) Cubits
Nao (Warship)	356	12	B/3 to B/2 (B/2)	4.5	7	6	10.75
Nao (Merchantman)	296	12	-	3.5	6	7	8.5

In his treatise, Cano described only the deck configuration of the master frame for his *nao* designs. If the vessel was designed as a warship, the ship's official breadth (*manga*), which also corresponded to its maximum breadth, should be situated at a height (*puntal*) of six cubits measured vertically from the floor flat (*plan*).[51] The main deck (*cubierta*) was located one cubit above the ship's maximum breadth or at seven

[49] Cano and Dorta 1964, 61.
[50] Cano and Dorta 1964, 107, 110.
[51] Cano and Dorta 1964, 109.

cubits. The gunports (*portas de la artillería*) of the main deck would be placed one cubit above the main deck, and two cubits from the waterline. When the gunports were placed at this level, no water would enter through them when sailing abeam with the ship fully laden with ballast, provisions, and victuals. Finally, the upper deck (*puente*) was situated 3.75 cubits above the main deck, and incorporated hatches fitted with wooden gratings (*cuarteles de ajedrez*) (Table 35) (Figure 35).[52] Once again, however, there was no description of the shape of the midship section, or the method employed to define it. The warship incorporated a row of unplanked beams to reinforce the hull at a height of 4.5 cubits, only 2.5 cubits below the main deck. The weight of the guns and soldiers carried on the main deck necessitated lowering as much as possible the height between the row of unplanked beams and the main deck.[53] Cano did not indicate the specific length for the floor of the master frame. However, he mentioned that it should range between the traditional 1/3 of the breadth used in Spain, Italy, and other nations, and the new ratio that Juan de Veas recommended of 1/2 of the maximum breadth (Figure 35).[54]

The text also included the first written reference in a Spanish shipbuilding manuscript of the application of deadrise (*astilla muerta*) to the floor of the master frame. According to Cano, the floor of the master frame should have a deadrise of 1/3 of a cubit, while the rising of the fore- and aft- tailframes was equal to ¾ of a cubit. The difference between the two values, approximately ½ cubit, was to be distributed between

[52] Cano and Dorta 1964, 67.
[53] Cano and Dorta 1964, 83-4.
[54] Cano and Dorta 1964, 62, 83, 102.

the frames forward and abaft of the master frame using the half-moon (*mezzaluna*) method.[55] Therefore, the main floor of the ship would result in an ovoid shape instead of square as with the vessels built by other shipwrights (Figure 35).[56]

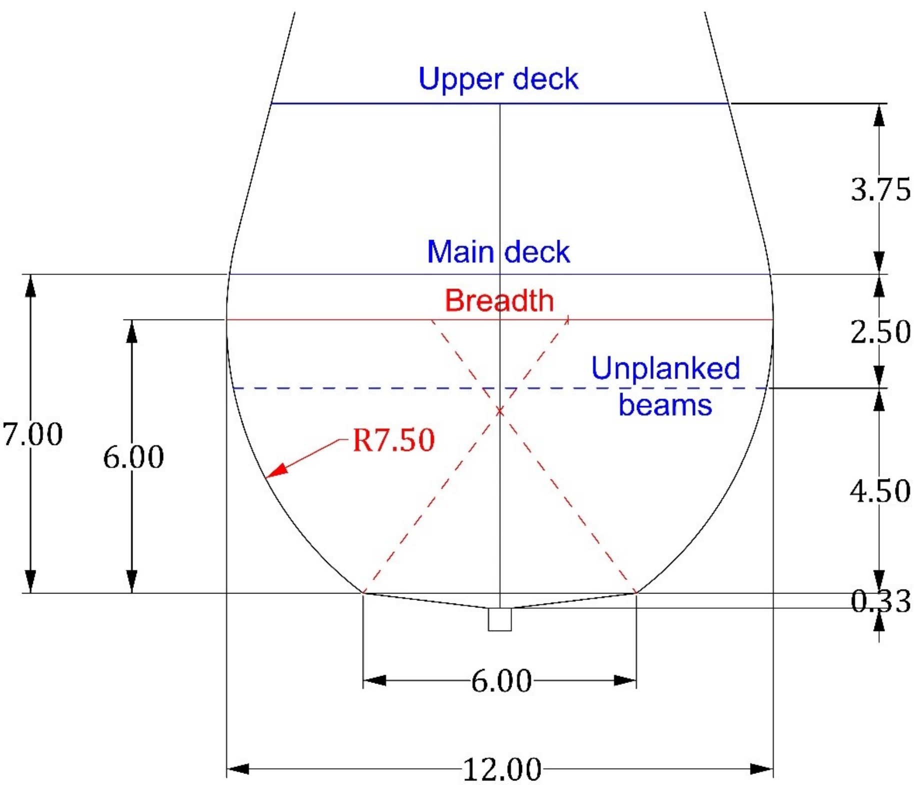

Figure 35. Cano's master frame for a warship. Units are in Castilian cubits (1 cubit = 0.558 m) (drawing by J. Casabán).

The last design innovation proposed in Cano's treatise is the *joba*.[57] The *joba* determined the tilting or pulling outward of the head of the futtocks with respect to their

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[55] Cano and Dorta 1964, 102-3.
[56] Cano and Dorta 1964, 103; Palacio 1944, 92v.
[57] Cano and Dorta 1964, 104-5, 108.

lower end at the wrongheads, without modifying their original curvature defined by the mold used for the master frame (Figure 36). In fact, the *joba* did not affect the design of the master frame but did so for the rest of the frames. The measurement of the *joba* was applied with the rising and narrowing of the floors, and ship's breadth to define the form of the hull, from the keel to the main deck. The progressive tilting outward of the futtocks forward and aft of the master frame up to the tailframes reduced the ship's draft while increasing ship stability. The end result was a reduction of ballast requirements, thereby producing faster vessels.[58]

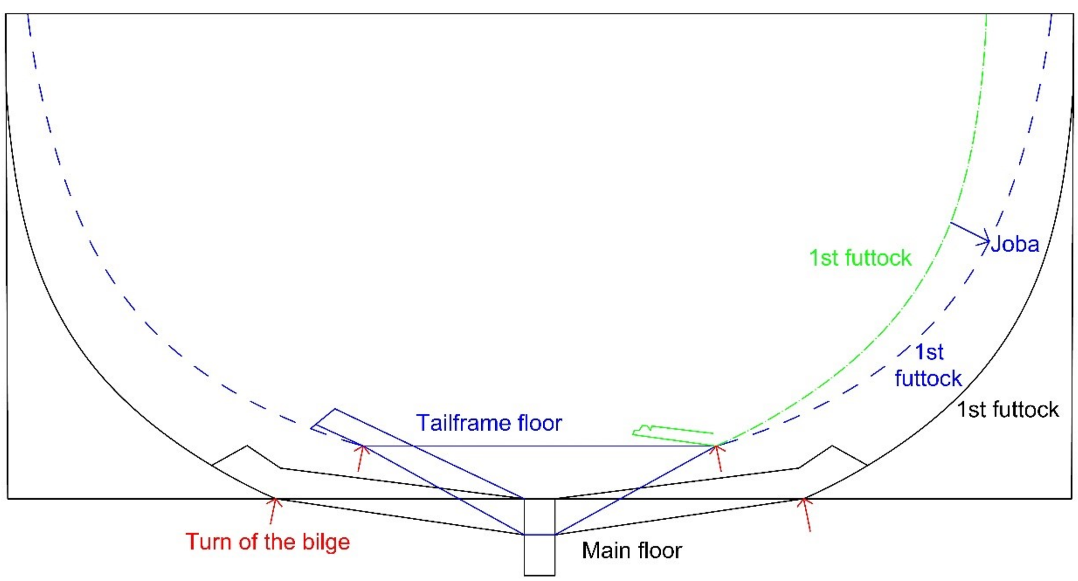

Figure 36. Application of the *Joba* (modified from Gaztañeta et al. 1992, 2: 53. fol. 62v, figure not numbered).

[58] Gaztañeta et al. 1992, 2:23.

Finally, the increased stability also made girdling of the hulls unnecessary.[59] The total amount of the tilting outward, or *joba*, was distributed among the futtocks using a geometrical method such as the half-moon (*mezzaluna*).[60] However, it is unclear to which part of the futtock the *joba* was applied.[61] Although Cano provides the first reference about the use of *joba* in Spanish shipbuilding, this design concept was probably originally introduced and developed by Captain Juan de Veas.[62] The design that Cano proposed for a 12-cubit breadth merchantman introduced various modification with respect to the warship design. This new design modified the configuration of the master frame and increased the length of hull, although it maintained the breadth, length of the keel, length of the main floor timber and its rising (Table 35).[63] Cano also presented a different concept of depth of hold (*puntal*), which included the vertical distance from the floor timber to the upper deck measured at the master frame.[64] The row of unplanked beams was situated at 3.5 cubits above the main floor timber, with the main deck (*primera cubierta*) at 6 cubits, and the upper deck (*segunda cubierta*) at 8.5 cubits. The ship's breadth, which corresponded to it maximum width, was situated at a height of 7 cubits, one cubit above the main deck, and one cubit higher than in the warship design (Table 35) (Figure 37).[65]

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[59] Gaztañeta et al. 1992, 1:22.
[60] Gaztañeta et al. 1992, 1:29.
[61] Gaztañeta et al. 1992, 1:31.
[62] Gaztañeta et al. 1992, 1:23.
[63] Cano and Dorta 1964, 91.
[64] Cano and Dorta 1964, 92.
[65] Cano and Dorta 1964, 91.

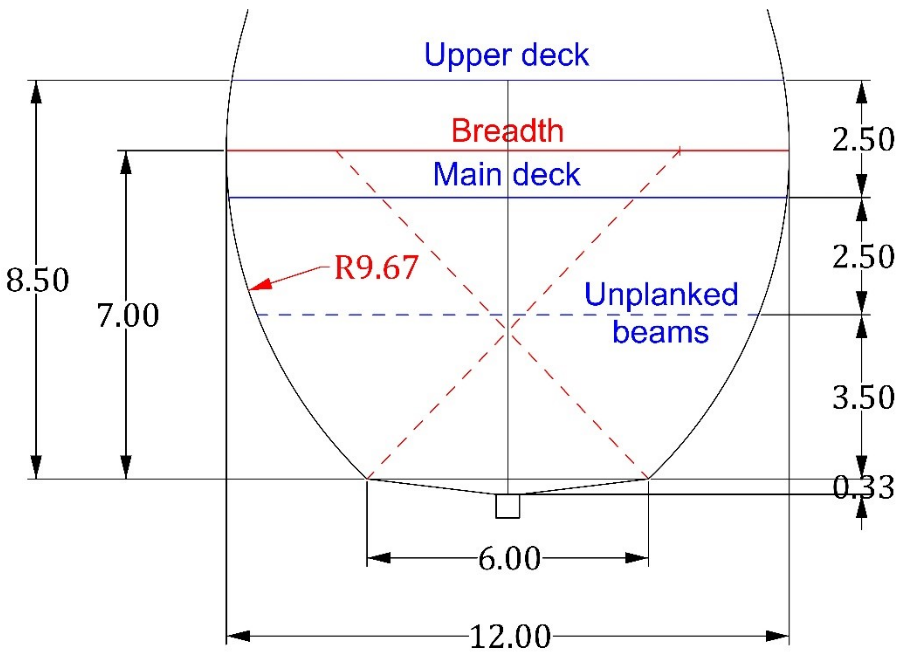

Figure 37. Cano's master frame for a merchantman. Units are in Castilian cubits (1 cubit = 0.558 m) (drawing by J. Casabán).

The depth of hold (*puntal*) was defined in relation to the maximum cargo capacity of the vessel measured up to the upper deck. According to Cano, this was the way ships were built in Portugal and Andalusia, and used to be built in Biscay in the past.[66] In fact, this is the same definition of depth of hold provided by Oliveira for his design of a Portuguese *nao* of 600 tons.[67] However, Escalante still defined the real depth of hold as the vertical height measured from the main floor timber to the main deck. It

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[66] Cano and Dorta 1964, 94.
[67] Oliveira 1991, 166; Palacio 1994, fol. 90.

should be noted that Cano himself was a ship owner of the Atlantic Andalusian coast and his shipbuilding knowledge was surely based on the usual ship design of this area.

The analysis of the designs that Cano proposed for both warship and merchantman reveal similar issues as the designs proposed in the Ordinances of 1607. The dimensions for both ship types and their configurations prevent the possibility of defining the sides of the master frame with a single circle. It is necessary, once again, to use two arcs with their centers located at the level of the ship's maximum breadth but separated with respect to the central axis of the midship section. Interestingly, the radii of the arcs used for the merchant vessel are longer than the corresponding ones used on the warship. In other words, Cano's designs produce a lower and wider master frame in the case of the merchantman to increase the cargo capacity. The warship's master frame, on the other hand, presents a slender design to favor speed and maneuverability, although both ships have identical breadth.

The Ordinances of 1613

The new set of shipbuilding ordinances issued in 1613 included more detailed information in relation to the dimensions and technical specifications of the ships, but limited references about the shape of the master frame. The ordinances also listed the value of the *joba* to be applied to the frames of each vessel according to its dimensions. These Ordinances classified the vessels, according to their breadths and tonnages, as dispatch vessels (*pataches*), ships (*navíos*), and galleons (*galeones*) (Table 36).[68] Although the Ordinances included dimensions for galleons with breadths up to 22 cubits, none of the designs included ships with more than two decks, as in the previous set of Ordinances.

Table 36. Ordinances of 1613.

Type of vessel	**Tonnage** (*toneladas*)	**Breadth** Cubits	**Floor (Deadrise)** Cubits	**Unplanked Beams** Cubits	**Main deck (Depth of hold)** Cubits	**Maximum breadth (height)** Cubits	**Upper deck** Cubits	**Tumblehome** Cubits
Dispatch vessel (*Patache*)	55	8	4 (M/2) (0.33)	-	3.75	3.75	-	
Dispatch vessel (*Patache*)	70.5	9	4.5 (0.33)	-	4	4	-	
Dispatch vessel (*Patache*)	94.5	10	5 (0.417)	-	4.5	4.5	-	
Ship (*navío*)	148	11	5.5 (0.417)	-	5	5	-	
Ship (*navío*)	207 3/4	12	6 (0.5)	DOH/2	6	6 (merchantman) 5.5 (warship)	2.66 (merchantman) 2.33 (warship)	
Ship (*navío*)	258 1/8	13	6.5 (0.5)	DOH/2	6.5	6.5 (merchantman) 6 (warship)	3	
Galleon (*galeón*)	316	14	7 (0.583)	DOH/2	7	7 (merchnatman) 6.5 (warship)	3	
Galleon (*galeón*)	381	15	7.5 (0.625)	DOH/2	7.5	7.5 (merchantman) 7 (warship)	3	
Galleon (*galeón*)	456	16	8 (0.66)	DOH/2	8	8 (merchantman) 7.5 (warship)	3	
Galleon (*galeón*)	539 ¼	17	8.5 (1.06)	DOH/2	8.5	8.5 (merchantman) 8 (warship)	3 1/8	
Galleon (*galeón*)	632	18	9 (0.75)	DOH/2	9	9 (merchanman) 8.5 (warship)	3 1/6	
Galleon (*galeón*)	721 ¾	19	9.5 (0.8)	1 row DOH/2	9.5	9.5 (merchantman) 9 (warship)	3.25	
Galleon (*galeón*)	833	20	10 (0.83)	2 rows DOH/3	10	10 (merchantman) 9.5 (warship)	3.25	
Galleon (*galeón*)	956	21	5.5 (0.875)	2 rows DOH/3	10.5	10.5 (merchantman) 10 (warship)	3.25	
Galleon (*galeón*)	1073 1/3	22	11 (0.917)	2 rows DOH/3	11	11 (merchantman) 10.5 (warship)	3.25	Same as in the unplanked beams (3.5 cubits below the main deck)

68 AGI *Indfiferente*. 2595, in Serrano Mangas 1992, 211-36.

As in previous shipbuilding treatises and manuscripts, only a small set of main dimensions referred to the design of the master frame. These Ordinances determined that the depth of hold and the length of floor equaled half of the ship's breadth. The official breadth, and maximum width of the master frame, was to be located at the same height as the main deck if the ship was designed as a merchantman, and ½ cubit lower if built as a warship (Table 36). According to Phillips, warships had their maximum breadth situated ½ cubit below the main deck to improve the stability of the ships because the heaviest artillery was carried at this level, close to the center of the ship.[69] However, it is more reasonable to think that the ship's maximum breadth was located below the main deck in an attempt to increase the distance between the waterline and the gunports. The merchant vessels, on the other hand, had the main deck at the same level as the maximum breadth. This difference was related to the system of calculating the tonnage of merchant ships when taken into service for the Crown (*embargo*).[70] In addition, the cargo capacity of the merchant vessels also increased if the maximum breadth was located ½ cubit higher, matching the height of the main deck, with respect to the design of warships. The height between the main deck (*cubierta principal*) and the upper deck (*puente*), on the other hand, ranged between 2.33 and 3.25 cubits, depending on the breadth of the vessel for both warships and merchant vessels (Table 36).

The only references to the design of the master frame are related to the rising (*astilla muerta*) applied to the main floor, and how all the frames must be shaped using

[69] Phillips 1992, 55.
[70] Rubio Serrano 1991, 44.

the mold (*grúa*) used for the midship section.[71] The Ordinances specified the total amount of rising (*astilla muerta*) to be applied to master and tailframes, and how it had to be distributed. While the total amount of rising was applied to the tail frames, only 2/3 of the total was applied to the floor of the master frame. The remaining 1/3 of the rising was distributed in equal parts between the second frames forward and aft of the master frame until the tailframes. The Ordinances also specified how to distribute the *joba* between the frames, although this dimension was not applied to the design of the futtocks of the master frame (Table 36).

One of the most interesting references to the design of the master frame was provided in section 20. This section described the tumblehome of the master frame for all vessels to ensure their seaworthiness, with good floatability, and that it was neither too wide nor narrow above the main deck. The tumblehome of the hull at the level of the upper deck (*puente*) was equal to the outward curvature of the hull at the level of the row of unplanked beams, located 3.5 cubits below the main deck. Above the upper deck, the bulwark had to straighten slightly to allow sufficient space on the upper deck.[72] However, in section 29 it is indicated that ships with breadths of up to 19 cubits should have a row of unplanked beams situated at a height equal to half of the depth of hold. On the other hand, ships with breadths above 19 cubits would have two rows of unplanked beams equally distributed between the floor (*plan*) and the main deck (*cubierta*).[73]

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[71] *Sección* 19, in Serrano Mangas 1992, 222-23.
[72] *Sección 20*, in Serrano Mangas 1992, 223.
[73] *Sección* 29, in Serrano Mangas 1992, 222-24.

The graphical analysis of the designs provided by these Ordinances shows again that both sides of the master frame cannot be defined with a single circle, neither for the warships nor merchantmen. Two independent arcs are still needed to define either side of the midship sections, and the arcs of the merchantman master frame also require a longer radius than the warship's midship section. On the other hand, the differences between the two types of midship sections are not as accentuated as in Cano's designs. However, it is possible to define either side of both types of master frames with a single arc up to the level of the vessel's maximum breadth. Moreover, if the tumblehome at the level of the upper deck equaled the curvature of the hull at the height of the unplanked beams, it was possible to define the midship sections of all warships up to 16-cubit breadths. In fact, in the case of the 16-cubit breadth galleon, a single continuous arc could be used to define either side of the midship section from the main floor to the upper deck (Figure 38).[74] The midship sections of the narrower warships may also be almost defined by a single arc, although a tangent straight line is needed near the upper deck level to complete the arc. The warships with breadths greater than 16 cubits, on the other hand, required another arc starting from the level of the maximum breadth up to the upper deck in order to complete the master frame according to the specified tumblehome (Figure 38). However, this arc could be defined with the same radius used in the arc that joined the main floor with the ship's maximum breadth. In other words, it

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[74] Rubio Serrano (1991, 2:89) proposes the 16-cubit breadth galleon as the prototype for all of them. It is the galleon in which the dimensions seem to fit better. Indeed, no larger galleons (17 cubits) were accepted for the Indies run due to the draft and sandbars issues.

was possible to define the entire midship section of a warship using a single mold (*grúa*).

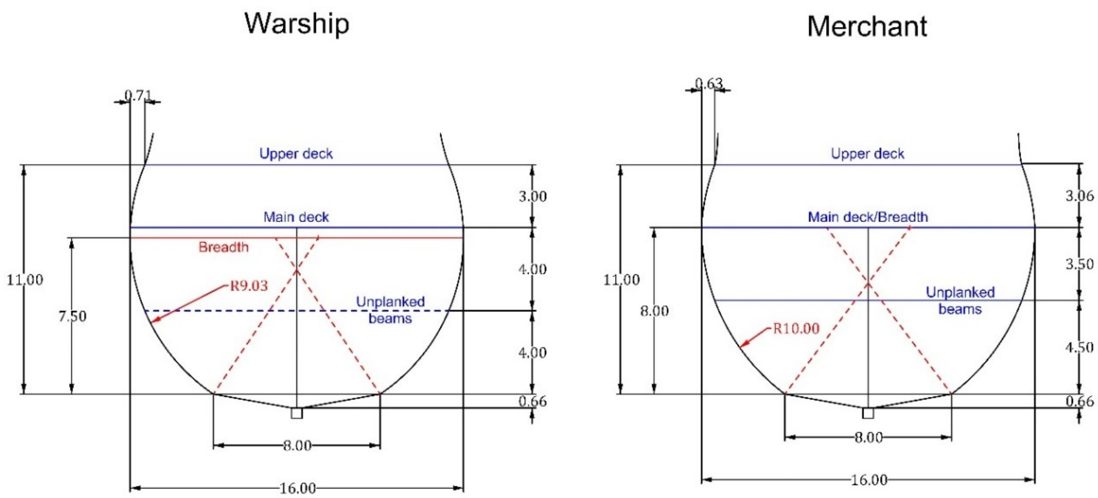

Figure 38. Warship and merchantman midship sections based on 1613 Ordinances. Units in cubits (1 cubit = 0.575 m) (drawing by J. Casabán).

The designs for the merchantmen, on the other hand, placed their maximum breadths ½ cubit higher than those of the warships, independent of their breadths. Therefore, it was impossible to define their midship sections with a single arc beyond the level of their maximum breadth. Moreover, the higher location of a ship's maximum breadth increased the radius of the arcs used to define the sides of the master frame. The variation of the shape of these arcs also increased the tumblehome at the level of the upper deck (Figure 38). Therefore, another arc was needed to complete the midship section of these vessels, as in the case of the warships with breadths above 16 cubits. This second arc could be defined with the same radius as that used for the arc joining the end of the main floor with the ship's maximum breadth, as in the case of larger warships. The only difference was that merchantmen had more tumblehome than their warship counterparts even when they were designed with the same breadths (Figure 38). Nevertheless, the same mold could be employed to define the whole midship section, as in the case of warships.

The Ordinances of 1618

A third set of Ordinances was issued in 1618 to correct the deficiencies observed in the previous set of 1613. In the new regulations, all vessels were classified as ships (*navíos*), with breadths ranging between nine and 22 cubits (Table 37). As in the previous Ordinances, these also included the ships' main dimensions and scantlings, but more detailed instructions about how to build the ships. Once again, all the linear units used for the construction of the ships were provided in Royal cubits (*codos reales*).[75]

The Ordinances also provided the ship's breadth (*manga*), length of the main floor timber (*plan*), the depth of hold (*puntal*), the height to the maximum breadth of the ship (*lo más ancho*), the height between the main and the upper decks (*cubierta principal* and *puente*), the rising of the floor (*astilla muerta*), and the value for the *joba*. The length of the main floor and the depth of hold equaled half of the ship's breadth, as in the previous set of Ordinances. On the other hand, the location of the ship's breadth, or maximum width, varied again. This time, the ship's breadth was situated ½ cubit

[75] Boix 1841, 4:20-32.

below the main deck, whether the vessel was designed as a warship or a merchantman (Figure 39). Basically, the main dimensions proposed in the Ordinances of 1613 for the midship section of warships were adopted for all ships types in the Ordinances of 1618.

Table 37. Ordinances of 1618.

Type of vessel	**Tonnage** (*toneladas*)	**Breadth** Cubits	**Floor (Deadrise)** Cubits	**Main deck (Depth of hold)** Cubits	**Maximum breadth (height)** Cubits	**Upper deck** Cubits	**Tumblehome** Cubits
Ship (*navío*)	-	9	4.5 0.33	4.5	4	-	-
Ship (*navío*)	-	10	5 0.33	5	4.5	-	-
Ship (*navío*)	157	11	5.5 (0.42)	5.5	5	-	-
Ship (*navío*)	198	12	6 (0.46)	6	5.5	-	-
Ship (*navío*)	251	13	6.5 (0.5)	6.5	6	9.5 (+3)	-
Ship (*navío*)	409 ½	14	7 (0.5)	7	6.5	10 (+3)	-
Ship (*navío*)	371 ½	15	7.5 (0.5)	7.5	7	10.5 (+3)	-
Ship (*navío*)	444 ½	16	8 (0.625)	8	7.5	11 (+3)	-
Ship (*navío*)	530	17	8.5 (0.66)	8.5	8	11.5 (+3)	-
Ship (*navío*)	624 1/8	18	9 (0.71)	9	8.5	12 (+3)	-
Ship (*navío*)	721 3/4	19	9.5 (0.75)	9.5	9	12.5 (+3)	-
Ship (*navío*)	821 7/8	20	10 (0.8)	10	9.5	13 (+3)	-
Ship (*navío*)	946 ½	21	10.5 (0.83)	10.5	10	13.5 (+3)	-
Ship (*navío*)	1074 ¾	22	11 (0.875)	11	10.5	14 (+3)	Same as in the unplanked beams (3.5 cubits below the main deck

However, minor variations between design proposals were also introduced. For instance, the height of the upper deck (*puente*) was limited to 3 cubits above the main deck (*cubierta principal*) in ships with breadths above 12 cubits, while the smaller vessels had only one deck (Table 37).[76] The deadrise of the main floor (*astilla muerta*) ranged between 0.33 and 0.875 cubits, slightly shorter than the deadrise values indicated in the Ordinances of 1613 (Tables 36 and 37). Nevertheless, the deadrise and *joba* were distributed among the floors and futtocks in the same way as in the previous Ordinances. Moreover, the location and distribution of the row of unplanked beams followed the same pattern as the Ordinances of 1613, including the discrepancies about the height at which it should be located.[77]

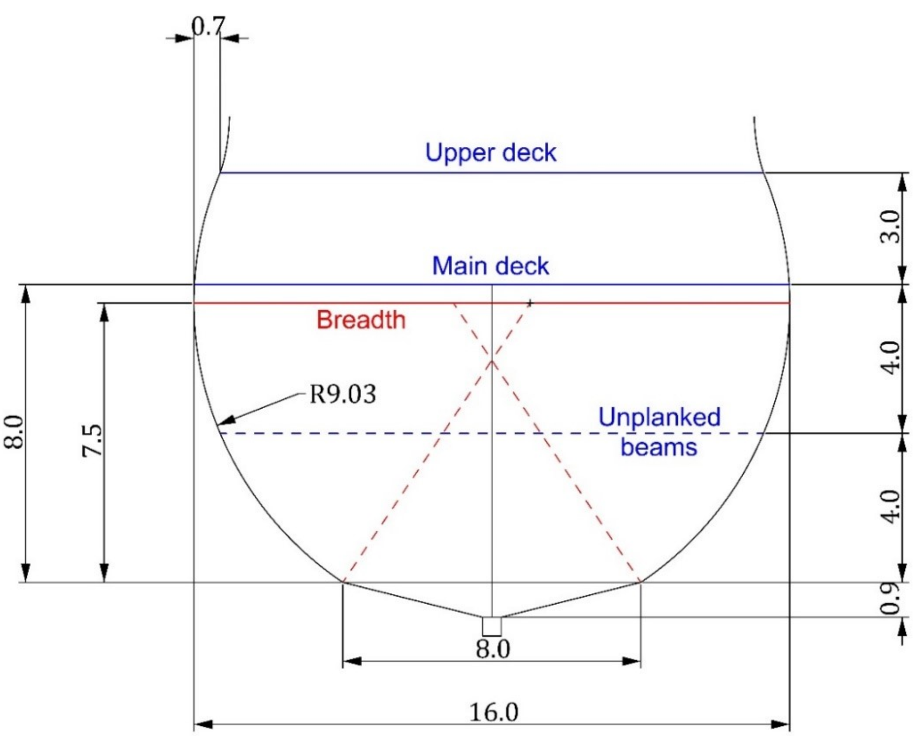

Figure 39. Midship section based on the Ordinances of 1618 (drawing by J. Casabán).

[76] Boix 1841, 4:21-5.
[77] See *Secciones* 22 and 32 of the *Ordenanzas* of 1618 in Boix 1841, 4:26-7.

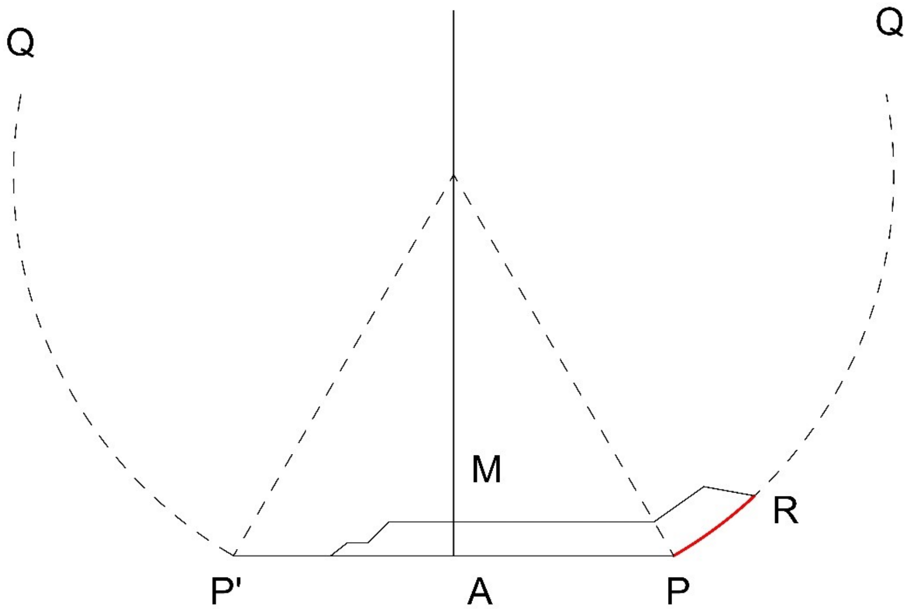

Figure 40. Arc for designing futtocks according to Gaztañeta (modified from Gaztañeta et al. 1992, 1:26, figure 16).

The Ordinances of 1618 also provided more detailed information about the shape of the arcs used in defining the master frames of the ships. According to section 15, the mold (*grúa*) of the lower end of the futtock (*pie de genol*) for the main floor timber (*primera orenga de en medio*) was to be applied to define the arcs of all the first futtocks (*ornizón*), the frame timbers (*ligazón*) forward and aft of the master frames, and even the fashion pieces (*aletas*) of the hull, without any modification.[78] In other words, the shape of the master frame was defined by a single arc with the same radius as that of the wrongheads of the floor timber. This arc extended from the point marking the turn of the bilge in the main floor (*punto de escoa*) up to the height of the ship's maximum breadth

[78] Boix 1841, 4:25.

(Figure 40). From that point, the ship's tumblehome followed the same design specifications as in the 1613 Ordinances and, therefore, the midship section could be defined in an identical manner. [79]

The method proposed in the 1613 and 1618 Ordinances to define the midship section of vessels matches closely those illustrated by Gaztañeta and Garrote as examples of traditional Spanish designs during the late 17th century.[80] Nevertheless, there are also important differences between them, such as the fact that these authors used a single circle to define the master frame of the vessels (Figure 41).

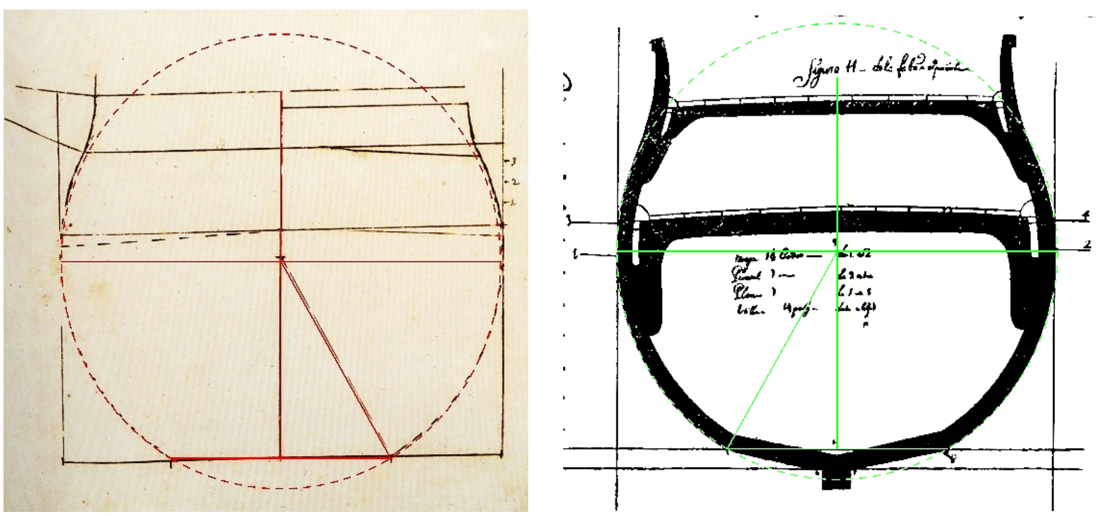

Figure 41. Traditional 17th-century master frame design in Spain according to Gaztañeta (left) (modified from Gaztañeta et al. 1992, 2:55, fol. 63v, figure not numbered), and Garrote (right) (modified from Artíñano y de Galdácano 1920, 122, figure not numbered).

[79] See *Secciones* 22 and 32 of the *Ordenanzas* of 1618 in Boix 1841, 4:26-7.
[80] Gaztañeta et al. 1992, 2:55, fol. 63v, and Artíñano y de Galdácano 1920, 122

The 1618 Ordinances were valid until the late 17th century, although the designs underwent minor modifications after their publication, as several shipbuilding contracts from the period illustrate. Moreover, new ideal sets of measurements for three-decked galleons with breadths of 17.5 and 18 cubits, and tonnages of 500 and 700 tons, were issued in 1666.[81] Finally, another modification was applied in 1679, although it only affected the 19-cubit breadth galleons that also became three-decked galleons.[82]

Dialogo entre un Vizcayno y un Montañés sobre la fábrica de navíos *(ca. 1631 – 1632)*

In addition to the different sets of Ordinances issued in the early 17th century, other shipbuilding manuscripts were written modifying the official ship designs. One of the most important shipbuilding manuscripts written after the 1618 Ordinances was López de Soto's *Dialogo entre un Vizcayno y un Montañés sobre la fábrica de navíos*. [83]

López de Soto wrote the manuscript in order to correct the flaws that he observed in the galleons built following the 1618 Ordinances. Moreover, his designs were intended to build galleons that could serve in the Indies run and other locations, as either warships or merchantmen, without having to modify them considerably or in an expensive way.[84] In the manuscript, López de Soto proposed ideal designs for galleons

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[81] Boix 1841, 4: 32-3.
[82] Boix 1841, 4: 37-8.
[83] According to the study conducted by Vicente Maroto (1998, 23-6), this manuscript was written by Pedro López de Soto, who also built several galleons for Philip II in the late 16th century while he was the *veedor* (inspector) and *contador* (accountant) in Lisbon.
[84] Vicente Maroto 1998, 179.

(*galeones*) of 14 to 22 cubits of breadth, and dispatch vessels (*pataches*) with breadths between 10 and 13 cubits (Table 38).[85] The only difference with the previous Ordinances was that Lopez de Soto did not include a design for the 9-cubit breadth vessels.

Table 38. López de Soto (1631-1632).

Type of vessel	**Tonnage** (*toneladas*)	**Breadth** Cubits	**Floor (Deadrise)** Cubits	**Unplanked Beams** Cubits	**Orlop deck** Cubits	**Main deck (Depth of hold)** Cubits	**Maximum breadth (height)** Cubits	**Upper deck** Cubits	**Tumblehome** Cubits
Galleon (*galeón*)	1200	22	11 (0.5)	4.5	9	12	10 to 11	15.5	3 2/3 to the gunwale (B/6)
Galleon (*galeón*)	-	21	10.5	-	8.5	11.5	9.5 to 10.5	15	(B/6)
Galleon (*galeón*)	-	20	10	-	8	11	9 to 10.5	14.5	(B/6)
Galleon (*galeón*)	-	19	9.5	-	7.5	10.5	9 to 9.5	14	(B/6)
Galleon (*galeón*)	-	18	9	-	7	10	8 to 9	13.5	(B/6)
Galleon (*galeón*)	-	17	8.5	-	6.5	9.5	7.5 to 8.5	13	(B/6)
Galleon (*galeón*)	-	16	8	-	6.25	9	7 to 8	12.5	(B/6)
Galleon (*galeón*)	-	15	7.5	-	5.75	8.5	6.5 to 7.5	12	(B/6)
Galleon (*galeón*)	-	14	7	-	5.25	8	7	11.5	(B/6)
Dispatch vessel (*patache*)	-	13	6.5	-	5.5	8	6 to 7	-	(B/6)
Dispatch vessel (*patache*)	-	12	6	-	5	7.5	5.5 to 6.5	-	(B/6)
Dispatch vessel (*patache*)	-	11	5.5	-	4.75	7.25	5 to 6.5	-	(B/6)
Dispatch vessel (*patache*)	100	10	5	-	4.5	7	4 to 5.5	-	(B/6)

[85] Vicente Maroto 1998, 169-78.

The manuscript provided the main dimensions related to the designs of midship sections of the vessels. These included the breadth, length of the main floor (*plan*), the depth of hold (*puntal*), and the height at which the breadth or maximum width (*más ancho*) of the vessels was measured. The deadrise (*astilla muerta*) was also listed, but only for the largest galleons. In the same way, the height of the upper deck (*puente*), with respect to the main deck (*cubierta*), was also indicated. Finally, the tumblehome of the upper deck was only included in the design specifications of the largest galleons, but probably the same method was used for the other vessels as well. As usual, there was no reference about the method used to define a ship's master frame, although there is no reason to believe that there were any changes with respect to the previous ordinances.

López de Soto designs, on the other hand, presented interesting variations with respect to the 1618 Ordinances in relation to the configuration of the midship sections. Among the most important changes was the introduction of a lower deck in place of the row of unplanked beams to serve as accommodation for the infantry and sailors, transforming the galleons into three-deckers although with only two decks of guns. Finally, the text explained for the first time why technical features, such as the deadrise of the floors, were applied to the design of the vessels.

The proposed lengths of floors were the same as in the Ordinances of 1618, equal to just half of the ships' breadths (Table 38). The manuscript mentioned a deadrise of only 0.5 cubits for the main floor for the largest galleon. This meant a reduction of more than ¾ of a cubit with respect to the measurement recommended in the Ordinances for a galleon of the same breadth. In addition, it is unclear if the same deadrise was applied to the other galleon sizes since it was equal to the smallest value that the Ordnances indicated for a 12-cubit breadth galleon. The main difference, however, between the manuscript and the Ordinances was the way in which it distributed between the ship's floors. This time the deadrise increased from the main floor up to the height of the runs and entries instead of only up to the tail frames. [86]

The galleons' depth of hold, measured up to the main deck, also increased in relation to the Ordinances of 1618. It increased by one cubit for the galleons with breadths between 22 and 14 cubits, and up to two cubits for all the others (Table 38). Moreover, the height at which the ship's full breadth, or maximum width, was measured also varied. In this case it was lowered by between 0.5 and two cubits with respect to the Ordinances, although the ships breadth was extended vertically, creating a deadflat, between one and 1.5 cubits (Table 38). The manuscript mentions the 22-cubit breadth galleon as the only vessel with a breadth above 19 cubits fitted with two rows of unplanked beams. The second row of beams, however, was converted into a deck to accommodate the infantry embarked on the ships.[87] In fact, all the ships were fitted with a lower deck, instead of a row of unplanked beams, located between 3 and 2.5 cubits below the main deck for the infantry (Table 38). The upper deck was located 3.5 cubits above the main deck in all galleons with breadths ranging between 22 and 14 cubits, while the smaller ones had only one deck (Table 38). [88] This supposed an increase of 0.5

[86] Vicente Maroto 1998, 171.
[87] Vicente Maroto 1998, 170.
[88] Vicente Maroto 1998, 169-71.

cubit with respect to the height specified in the Ordinances of 1618. The last difference between the manuscript and the Ordinances was related to the method of determining the tumblehome of the upper deck. De Soto proposed a different system in which the tumblehome of the 22-cubit breadth galleon equaled to 1/6 of the minimum breadth at the gunwale (*bordo*).[89] However, he did not specify if this was the total tumblehome for both or either side of the hull.

Despite this omission, López de Soto still proposed that half of the ship's maximum breadth be used for the length of the main floor (*plan*). He further recommended adding an extra cubit to the main floor of the 22-cubit breadth galleons, with a proportional increase to be applied to the rest of the vessels. This increase of the floor lengths would help the galleons to draw less water even when fully laden, keeping the gundeck sufficiently high above the waterline.[90]

In his opinion, the short floor lengths of Spanish galleons was one of their main design problems. Before the release of shipbuilding Ordinances, the floor lengths depended on the individual preferences of shipwrights, who normally gave them up to 1/3 of the maximum breadth, as in the case of the Twelve Apostles. For this reason, the ships had deep drafts that made it difficult for them to enter and leave shallow ports, risking running aground and wrecking. The Ordinances tried to solve this issue by increasing the floor lengths by up to half of the maximum breadth. Floors longer than this, however, increased the rolling of a ship, which, in turn, tended to open their hull

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[89] Vicente Maroto 1998, 181.
[90] Vicente Maroto 1998, 180.

planking causing them to leak and, ultimately, to sink. For this reason, Spanish shipwrights avoided using the floor lengths used by Flemish shipwrights on their ships due to the shallowness of the Flemish ports. Instead, the Spanish solved the problem of ship's roll by adding a deadrise to the floor of the master frame in order to increase the stability of the vessel. The Flemish, on the other hand, were unable to apply this deadrise to their midship sections because their ships tended to rest on the ground during low tide.[91]

According to Lopez de Soto, the application of the deadrise (*astilla muerta*) to the floor of the master frame, as well as to the rest of the bottom of the hull, had three main advantages. Firstly, the deadrise enhanced the ship's balance; secondly, it caused the ship's head to tend to windward; and thirdly, the ship became faster.[92]

Lopez de Soto also designed his galleons as three-deckers, although with only two decks of guns, by turning the rows of unplanked beams into lower decks to accommodate the crews and soldiers, as in the previous 16th-century designs such as that of the Twelve Apostles. His galleons became truly multipurpose vessels because their design allowed them to be converted into merchantmen by removing the planking of lower deck. Moreover, the merchant versions of these galleons had an extra cubit of depth of hold and a superior cargo capacity when compared to the designs of the 1618 Ordinances, such as the 22-cubit breadth galleons (Table 38). Finally, if a 0.25-cubit thick girdling was applied to either side of the hull at the water line, it would raising the

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[91] Vicente Maroto 1998, 180-1.
[92] Vicente Maroto 1998, 184.

height at which the ship's breadth was situated, making the vessel capable of carrying more cargo without increasing its draft while reinforcing the hull sides.[93]

The Ordinances of 1618 determined that the depth of hold of the galleons could not be higher than half of the ship's maximum breadth. As a result, the galleons built following these Ordinances were unable to use the artillery of the main deck because the gunports were positioned too low and close to the waterline. Therefore, many guns had to be moved to the upper deck, which was situated 3.5 cubits above the main deck.[94] The weight of the ordnance on the upper deck also raised the center of gravity of the vessel which, in turn, increased its ballast requirements, becoming heavier and slower. Moreover, during storms, the extra weight and volume of the hull on the upper deck could actually open the hull. Therefore, Lopez de Soto decided to add one extra cubit of depth of hold to prevent this situation. He defined the depth of hold (*puntal*) as the height measured along the main mast from the ceiling planking (*granel*) up to the first deck, below the deck planking.[95] By adding an extra cubit of depth of hold, Lopez de Soto expected that the guns would end up more than three cubits above the waterline in a 22-cubit breadth galleon. His calculations were based on the design of the midship section in which the expected waterline would be located at the level of the ship's maximum breadth, situated at 10 cubits above the ceiling planking. The main deck was

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[93] Vicente Maroto 1998, 179.
[94] In fact the Ordinances of 1618 situated the upper deck three cubits above the main deck. It was Soto who increased the height between decks ½ cubit, although he refers to this height as the one used in the previous Ordinances. He is probably referring to a type of *embono* (girdling) which consisted in extending a deck between the stern and forecastles; this created a new deck while the main deck was converted for use as cargo space. Vicente Maroto, 1998, 181.
[95] Vicente Maroto 1998, 181.

situated at 12 cubits, or two cubits above the ship's maximum breadth, with the gunports opened one cubit above the main deck. Therefore, the ordnance would be situated at least 13 cubits above the ceiling planking over the master frame (Figure 42).[96]

The addition of a lower deck was justified to prevent the infantry from occupying the main deck and hampering the gundeck with their equipment, chests, and olive-jars. In a 22-cubit breadth galleon, this deck was located nine cubits above the ceiling planking, and three cubits below the main deck. Therefore, the lower deck, and all its weight, were located one cubit below the waterline and three cubits below the main deck. This configuration contributed to reducing the weight and volume above the waterline, which, in turn, improved the sailing characteristics of the vessel, reducing the ballast requirements and keeping the ordnance ready for use at any time. Moreover, if additional provisions were needed for a longer journey, they could be carried on the infantry deck (orlop deck).[97]

The increase by 0.5 cubit in the height of the upper deck (*puente*), up to 3.5 cubits above the main deck with respect to the three cubits proposed in the 1618 Ordinances, was made in order to provide sufficient space between the two decks. In a naval engagement, the smoke from the guns would dispel more readily through the four hatches opened on top, fitted with wooden gratings that could be covered with tarred canvas in case of bad weather to protect the personnel below.[98]

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[96] Vicente Maroto 1998, 170-1, 181.
[97] Vicente Maroto 1998, 181.
[98] Vicente Maroto 1998, 184.

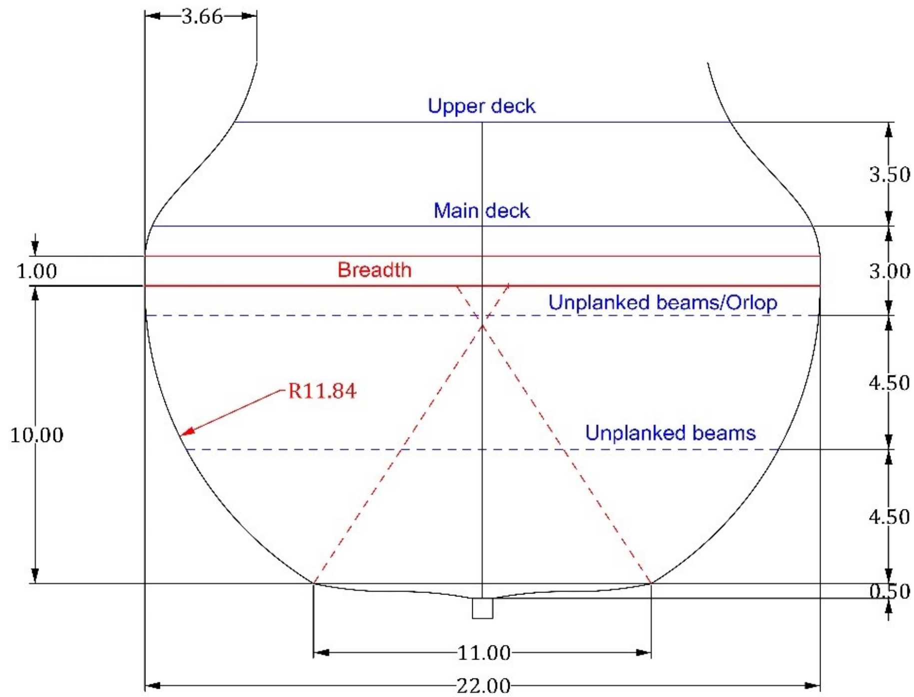

Figure 42. Master frame for López de Soto's 22-cubit breadth galleon (1631). Dimensions are in cubits (1 cubit = 0.575 m) (drawing by J. Casabán).

As usual, López de Soto’s manuscript does not provide any information about the method employed in defining the master frame of his galleons. On the other hand, it indicated several modifications in the deck configuration of the midship section, which affected the rest of hull design. However, there is no reason to suggest that there was a change in the method used for defining the ship’s master frame based on the use of a single circle for either side of the master frame, from the floor to the level of the ship’s maximum breadth. However, it is unclear if the recommended amount of tumblehome at the level of the gunwale, which equaled 1/6 of maximum breadth, was applied to the total breadth or to either side of the ship’s breadth.

The graphical representation of the master frame following Lopez de Soto's configuration shows that, when applying the tumblehome of 1/6 of the maximum breadth to either side of the hull, the space left on the upper deck was greatly reduced in comparison to those of previous designs. However, if the total amount of tumblehome was divided between either side of the master frame, the resulting shape became similar to the more traditional designs (Figure 43). In any case, it is clear that the modifications in the configuration of the master frame were directed toward correcting excessive draft while lowering the ship's center of gravity, and increasing its cargo capacity. The new design also ensured that there was sufficient distance between the guns and the waterline in order for the guns to be readily available in any sea condition or circumstance. This necessary condition was a recurring objective reflected in every warship design since the second half of the 16th century.

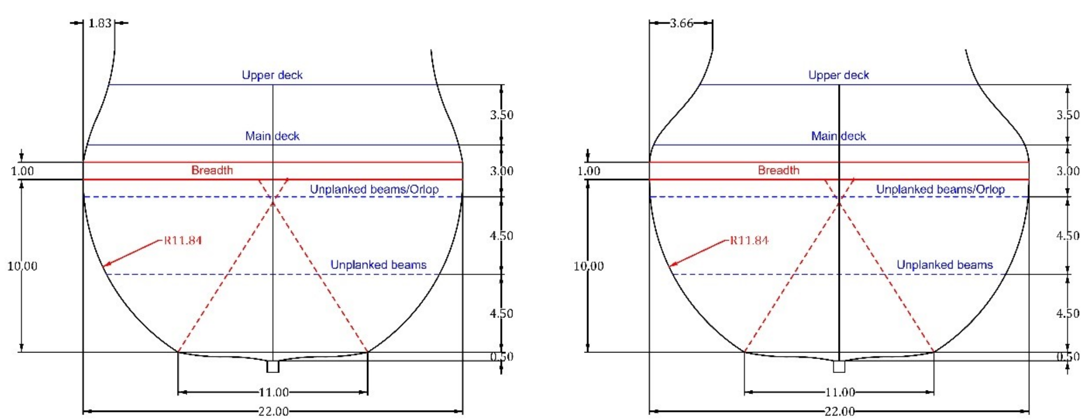

Figure 43. Comparison of the tumblehome in López de Solo's 22-cubit breadth galleon (1631). Units given in cubits (1 cubit = 0.575 m) (drawing by J. Casabán).

The Ordinances of 1666

The modification of the Ordinances of 1618 introduced in 1666 only affected the 17.5- and 18.5-cubit galleons with tonnages of 500 and 700 tons respectively. While their breadths increased 0.5 cubits with respect to the Ordinances of 1618, their tonnages were reduced by 30 and 24 tons, respectively (Table 39). Moreover, the 1666 modification also introduced again the three-decked galleons as Lopez de Soto had recommended in his manuscript, although with a different deck configuration. The objective of the modifications was to reduce the draft of the vessels, making them able to sail without danger over the Sanlucar's sandbar.[99]

Table 39. Ordinances of 1666.

Type of vessel	**Tonnage** (*toneladas*)	**Breadth** Cubits	**Floor (Deadrise)** Cubits	**Unplanked Beams** Cubits	**Main deck (DOH)** Cubits	**Maximum breadth (height)** Cubits	**Upper deck** Cubits	**Tumblehome** Cubits
Galleon	700	18.5	B/2 + 1/3 (1)	-	8.75	8.75	11.75	3.5 from the main deck (1.5 from 1st to 2nd, 2 cubits from 2nd to deck)
Galleon	500	17.5	B/2 + 1/4 (0.75)	-	8.25	8.25	11.25	

According to these Ordinances, the traditional length of the main floor, which equaled half of the ship's maximum breadth, was increased 0.25 cubit for the 500-ton galleons, and by 0.33 cubit for the 700-ton ships. The purpose of these increments was again to reduce the draft of the galleons because warships tended to draw more water

[99] Boix 1841, 4:32.

due to the weight of the guns they carried (Table 39).[100] Lopez de Soto had already recommended the increase of the length of the main floor in his manuscript 30 years earlier for the same reason.[101] Longer floor lengths, however, had a negative impact on the ships' stability producing vessels that tended to roll. In order to prevent this situation, the Ordinances of 1666 recommended to reverse the shape of the lower sides of the floors to avoid having a flat bilge (*pantoque*).[102]

The total deadrise for both galleons, on the other hand, was slightly reduced in comparison to the previous Ordinances of 1618. In the case of the 500-ton galleons, the total deadrise became 0.75 cubit instead of one cubit, while for the 700-ton vessels the deadrise was reduced by 0.6 cubit to become one cubit. Shipwrights were responsible for the distribution of the deadrise between the main floor and tail frames. These Ordinances, however, did not specify how the deadrise was to be distributed between the master frame and the tail frames, but the method was probably the same as in 1618, in which 2/3 of the total deadrise corresponded to that of the main floor.

There were also modifications made in relation to the height of the main deck at which the ship's maximum breadth was also located. According to the new Ordinances, the depth of hold was measured from the ceiling planking (*granel*) to the upper surface of the main deck, where the ship's maximum breadth was also measured. In this case, however, the ship's maximum breadth was not extended vertically as López de Soto had

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[100] Boix 1841, 4:33.
[101] Vicente Maroto 1998, 180.
[102] Boix 1841, 4:33.

proposed in his manuscript. The location of the ship's maximum breadth was another difference with respect to the 1618 Ordinances, in which the ship's breadth was located 0.5 cubit below the main deck. The depth of hold was reduced by 0.25 cubit for both the galleons with respect to the 1618 Ordinances, while the height at which the maximum breadth was measured increased by 0.25 cubit. The depths of hold were also 1.25 cubits lower than Lopez de Soto had recommended for galleons of similar breadths, while the ships' maximum breadths were also 0.75 cubit lower (Table 39). It should be noted that Lopez de Soto situated the ship's maximum breadth two cubits below the main deck, although he had extended it vertically for one cubit. This configuration allowed Lopez de Soto to place a lower deck below the main deck, while the 1666 Ordinances followed a different design.

These 1666 Ordinances introduced again the three-decked configuration for the galleons despite the reduced depth of hold of the vessels with respect to the 1618 specifications. This time, a second deck was added between the main deck and the upper deck with a height between decks of three cubits for both galleons. The main deck of the previous designs became the lower deck, although it was located approximately at the same level as the waterline, and not slightly under water as in the de Soto designs, or even in the designs of the Twelve Apostles. The ordnance, therefore, was placed on the second deck instead of the main deck, although there was no mention about this issue in the Ordinances. Since the main deck served as the first or lower deck, the galleons were still fitted with a row of unplanked beams to reinforce the lower part of the hull (Figure 44).

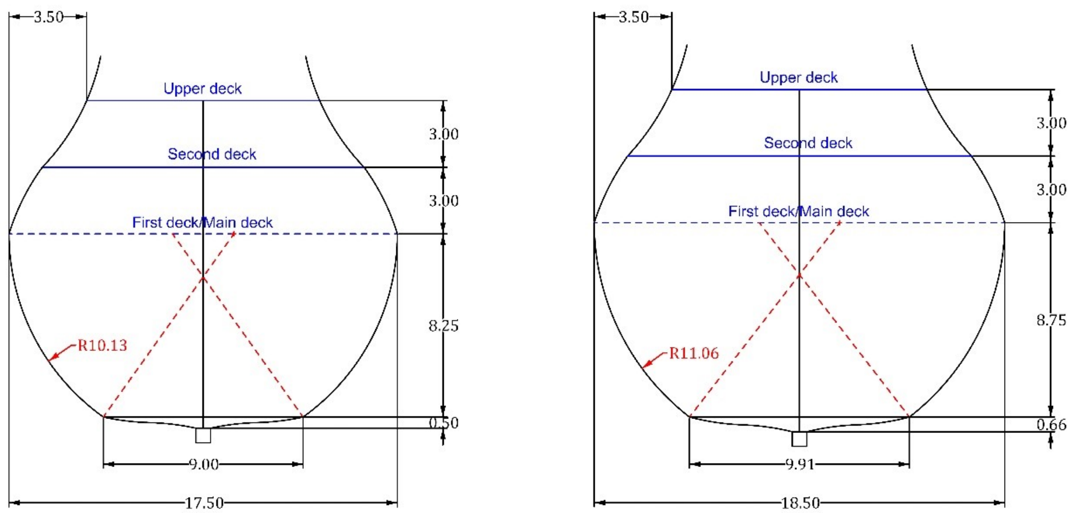

Figure 44. Midship sections of a 17.5-cubit (left) and 18.5-cubit (right) breadth galleons based on the Ordinances of 1666. Units given in cubits (1 cubit = 0.575 m) (drawing by J. Casabán).

The last difference between the sets of Ordinances of 1618 and 1666 was related to the method of determining the tumblehome of the galleons. In the new Ordinances, the tumblehome did not depend on the location of the row of unplanked beams, but it was progressive. The Ordinances determined a total tumblehome of 3.5 cubits at the level of the upper deck. The tumblehome between the first and second deck was 1.5 cubits while the remaining two cubits were applied between the second and the upper deck (Figure 44).[103]

The Ordinances of 1666 introduced modifications in the configuration of the ship's master frame that affected its shape, but not necessarily the method used to define it. Despite the modifications, it was still possible to use a single arc to join the point

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[103] Boix 1841, 4:33.

marking the turn of the bilge on the main floor with the ship's maximum breadth, as in the previous examples. Moreover, both the tumblehome and even the reverse design of the lower part of the main floor could be defined with the same mold used for the sides of the master frame (Figure 44).

The Ordinances of 1679

The modifications introduced by the 1679 Ordinances only affected the 19-cubit breadth galleons. The breadth of the galleons did not vary with respect to the Ordinances of 1618, although their tonnage increased from 721 ¾ to 800 tons. This new modification also introduced changes in the configuration of the master frame as well as variations in the main dimensions of the ship (Table 40).

Table 40. Ordinances of 1679.

Type of vessel	**Tonnage** (*toneladas*)	**Breadth** Cubits	**Floor (Deadrise)** Cubits	**Orlop deck** Cubits	**Main deck (Depth of hold)** Cubits	**Maximum breadth (height)** Cubits	**Upper deck** Cubits	**Tumblehome** Cubits
Galleon	800	19	9.75	6.25	9.25	9.75 to 10.38	12.5	1.5 cubits from the breadth to the gunwale Bulwark 1.25 cubits

The length of the main floor was increased by 0.25 cubit with respect to the 1618 Ordinance's original length, which equaled half the maximum breadth. The deadrise, on the other hand, was reduced to 0.66 cubit, although it is unclear if this was the total amount of deadrise for the tail frames, or only the deadrise for the main floor. If this deadrise had to be distributed between the master frame and tail frames, the resulting rising for the main floor would be 0.44 cubit, similar to the 0.5 cubit recommended by Lopez de Soto. However, the most significant changes affected the ship's depth of hold and the height at which the breadth was located (Table 40).

The depth of hold was reduced by 0.25 cubit in relation to the 1618 Ordinances, while the height for the maximum breadth increased by 0.75 cubit. This time the main deck was located 0.5 cubit below the ship's maximum breadth, which was also extended vertically by 1/3 of a cubit. This galleon became a three-decker in relation to its previous design of 1618. A second deck for artillery was added above the main deck, and below the upper deck, which was destined to accommodate the infantry embarked on the vessel. The height between decks also increased by 0.25 cubit to 3.25 cubits. These Ordinances did not mention the row of unplanked beams although they were probably located between the ceiling planking and the main deck. In addition, the ships had a circular tumblehome of 1.5 cubits on either side of the hull from the level of the maximum breadth to the gunwale (*bordo*) with a bulwark of 1.25 cubits (Table 40) (Figure 45).[104]

These Ordinances did not include any reference to the shape of the master frame, apart from the fact that its deck configuration differed from the previous designs. Nevertheless, the midship section could still be defined in the same way as the previous examples, using a single arc for either side up to the maximum breadth, and the same arc

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[104] Vicente Maroto1998, 37-8.

to complete the upper part of the hull. In addition, the tumblehome corresponded to almost half of the tumblehome recommended by the previous ordinances. This could possibly indicate that the total tumblehome of the 1666 Ordinances, and even that in Lopez de Soto's manuscript, was to be distributed between either side of the master frame. Finally, the Ordinances only mentioned that the tumblehome had to be circular but do not specify the type of circle, either convex or concave, with respect to the midship section. Therefore, the tumblehome could be defined using a combination of these arcs (Figure 45).

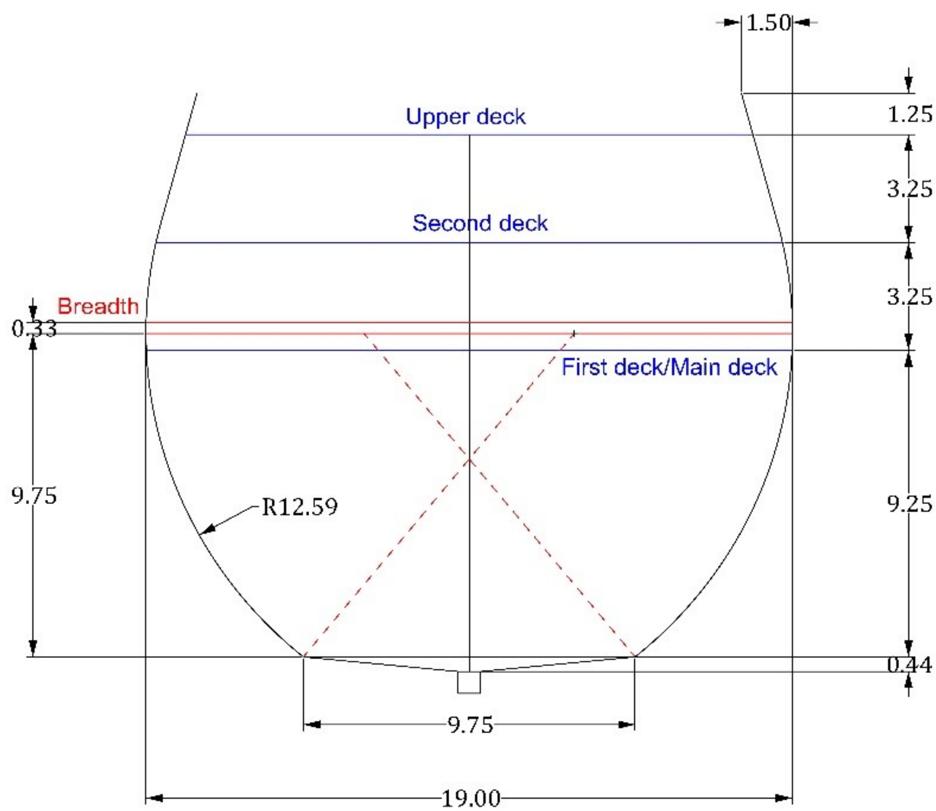

Figure 45. Master frame for a 19-cubit breadth galleon based on the Ordinances of 1679. Units given in cubits (1 cubit = 0.575 m) (drawing by J. Casabán).

Arte de fabricar reales *(1688)*

When Gaztañeta wrote *Arte de Fabricar Reales* at the end of the 17th century, the Ordinances of 1618 were still valid despite the minor modifications introduced in 1666 and 1679.[105] Gaztañeta's manuscript focuses on the construction of the *Capitana Real de la Armada del mar Oceáno* (Admiral's ship of the Royal Armada of the Ocean Sea), *Nuestra Señora de la Concepcion y de las Animas*, built in the shipyard of Colindres between 1682 and 1690, and the galleon *San Francisco,* built for the silver run (*la Carrera de la Plata*).[106] The rest of the text refers to the design methods of the main components of a galleon.[107] The manuscript is dated 1688, although it includes references to events that occurred earlier, such as the launching of the *Capitana* or previous construction stages.[108] The text is composed of the notes taken by Antonio de Gaztañeta when he was a shipwright apprentice, before he became responsible for the development of Spanish galleons of the 17th century to the *navío* (ship) of the beginning of the 18th century.[109] The manuscript compiled the construction sequence of the galleons, and also described the design of molds used to define the midship shape of the galleons, including how to obtain the main floors, futtocks, stem, sternpost, and other components of the hull.[110]

[105] Gaztañeta et al. 1992, 1:3.
[106] Gaztañeta et al. 1992, 1:7, 13.
[107] Gaztañeta et al. 1992, 1:9.
[108] Gaztañeta et al. 1992, 1:7.
[109] Gaztañeta et al. 1992, 1:12.
[110] Gaztañeta et al. 1992, 1:13, 15.

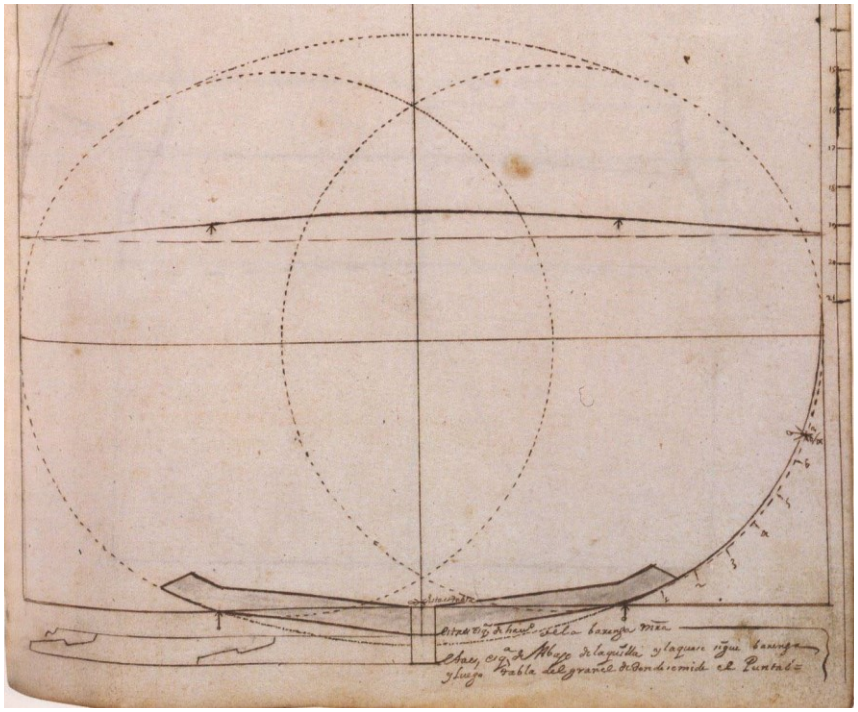

Figure 46. Creating a horizontal oval from two overlapping circles to design a midship section (after Gaztañeta et al. 1992, 2:53, fol. 62, figure not numbered).

Gaztañeta's manuscript, however, is especially useful for the explanation and illustrations he provided about the method to define the molds (*grúas*) and shape of the master frame. According to him, once the main dimensions of a vessel were decided, the shapes for the molds of the floor and futtocks of the master frame were traced on beach sand and transferred to wooden molds using a right triangle, a 10-cubit long stick, black string, a compass, an axe, an adze, a drill, nails, a hammer, and pine planks.[111]

Gaztañeta also described and represented graphically the new method used at the end of the 17th century to determine the *Capitana*'s master frame, which was based on a

[111] Gaztañeta et al. 1992, 1:83.

horizontal oval created from two overlapping circles (Figure 46). This method was described by Gaztañeta in his manuscript, and later by Garrote with some variations. It addressed the need of obtaining a wider hull section, to build a ship with increased stability and shallower draft using a simple design method. According to Gaztañeta, the oval method was used to design the *Capitana Real* with 90 guns, although the design would probably have been studied on paper first.[112]

In order to define the midship section, the maximum breadth of the vessel was divided into three equal parts, and the resulting two points were used as centers for two circles that defined either side of the master frame. The radius of each circle was equal to 1/3 of the ship's maximum breadth, while the length of the main floor initially was still equal to half of the maximum breadth whose full length was described by the arc of the resulting oval (Figure 46). Later, however, the main floor length became defined by a parallel segment to the ship's breadth whose length was equal to the distance between the intersection points of that line with the two circles at a height equal to the deadrise (*astilla muerta*).[113] In this later method described by Gaztañeta, the maximum ship's breadth was situated much lower with respect to the height of the main deck (Figure 46). In any case, the sides of the master frame were still defined by a single arc from the floor ends to the level of the ship's maximum breadth, although this level began much lower in comparison to the height of the main deck. Moreover, two circles were still used to

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[112] Gaztañeta et al. 1992, 1:16-7; Artíñano y de Galdácano 1920, 340-2.
[113] Gaztañeta et al. 1992, 1:17.

define the master frame as in the previous example, although their radii were shorter than in the previous method described.

In addition to the new method based on the oval, Gaztañeta also included in his manuscript the representation of another design for a master frame based on a single circle to define both sides of the frame (Figure 47). The illustration, however, was not accompanied with any explanatory text, although a very similar drawing was fully explained by Garrote in his 1591 shipbuilding manuscript.[114] According to Fernandez González, this was the traditional method used in Spain to define the midship section during the major part of the 17th century, until the introduction of the oval method.[115]

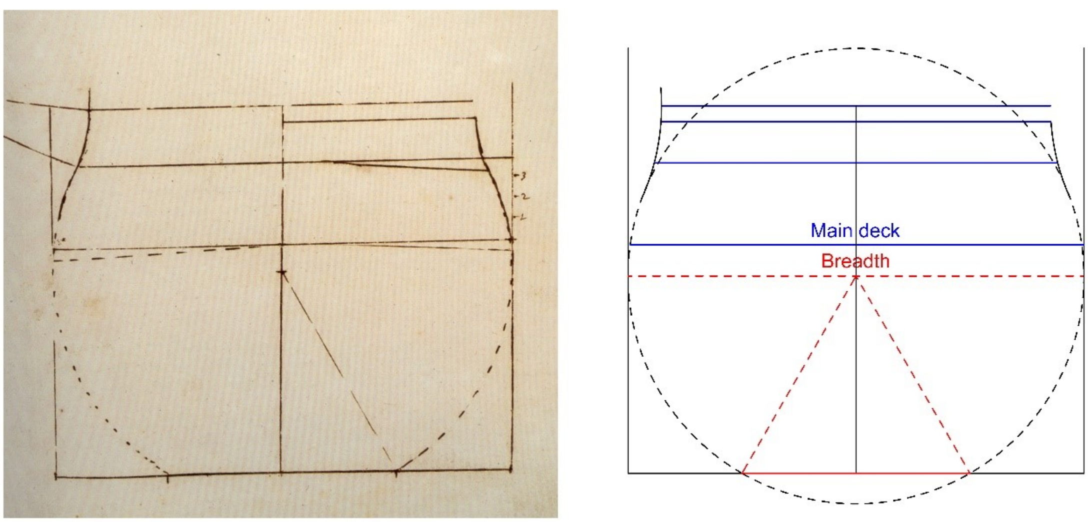

Figure 47. Traditional master frame design used in Spain during the 17th century according to Gaztañeta (left) (after Gaztañeta et al. 1992, 2:53. Fol. 63, figure not numbered), and its interpretation (drawing by J. Casabán).

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[114] Gaztañeta et al. 1992, 2:63. fol. 63; Artíñano y de Galdácano 1920, 341-2.
[115] Gaztañeta et al. 1992, 1:16.

Gaztañeta's illustration represents the master frame of a two-decked vessel in which the main floor length, depth of hold, and the radius for the arc of the futtock are equal to half of the ship's maximum breadth. The center of the arc was located in the upper vertex of an equilateral triangle whose sides had the same length as the main floor. The arc that defined the midship section continued up to the upper deck level to form the tumblehome. An arc with the same radius as that of the futtock of the master frame defined the shape of the bulwark above the upper deck (Figure 47).

The proportions between the breadth, length of floor, and depth of hold of the master frame are the same as those provided in the Ordinances of 1613 and 1618. However, the center of the circle that defined the master frame was located one cubit below the main deck, instead of the 0.5 cubit indicated in the Ordinances. This variation, on the other hand, had almost no impact on the height at which the ship's maximum breadth was located. According to the Ordinances, the ship's maximum breadth was located 0.5 cubit below the main deck. According Gaztañeta's design method, the maximum breath was located one cubit below the main deck, although if the ship's breadth was measured 0.5 cubit below the main deck, the resulting dimension was only 0.019 cubit (0.01 m) shorter, almost imperceptible for the shipbuilders. This difference, however, increased assuming the proportions between the main dimensions of the ship changed as the 17th-century shipbuilding programs showed.

According to Fernandez, this was the traditional method used in Spain to define the midship section during the major part of the 17th century, until the introduction of the oval method. However, this method also suffered modifications that affected the proportions between the main dimensions of the master frame, such as the addition of deadrise to the radius of the arc used to define the midship futtocks.[116] The objective was to obtain a design method that increased the breadth and reduced the depth of hold sufficiently to produce a stable vessel with less need of ballast and with guns located high enough above the waterline for them to be effective in most sea and weather conditions.[117]

Recopilación para la nueva fábrica de baxeles españoles *(1691)*

In 1691, Garrote proposed his own designs to reinforce ship's hulls while reducing their draft to allow them to safely cross the Sanlúcar sandbar. However, as with Gaztañeta, Garrote also did not publish his work, due probably to the introduction of a new design method based on plans and the geometric design of each frame, in other words the substitution of the galleon by the *navío*.[118]

Garrote mentioned in his manuscript that the main objective of every maritime nation was to build ships with shallow draft, and the gundeck located high enough above the waterline to be operative in any weather or sea condition. Therefore, shipwrights tended to lengthen the ship's main floor, but this resulted in vessels similar to those with floor lengths equal to half of their maximum breadth. The resulting vessels had difficulty in sailing close to the wind, and their gundecks were mostly useless because they were

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[116] Gaztañeta et al. 1992, 1:16.
[117] Gaztañeta et al. 1992, 1:16-7.
[118] Gaztañeta et al. 1992, 1:34-5.

located too close to the waterline. In order to correct this situation, other shipwrights preferred increasing the ship's depth of hold, which was even more harmful for the design of a warship. In Garrote's opinion, a good midship section design for a warship was based on a horizontal oval, and did not require a floor length larger than half of the maximum breadth, with a depth of hold equal to 2/5 of the same breadth. [119].

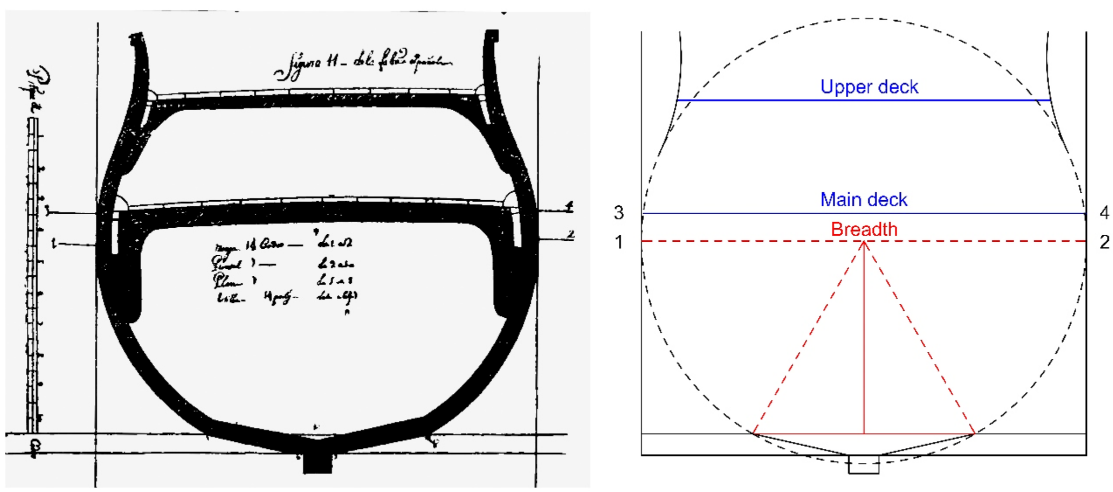

Figure 48. Traditional 17th-century master frame design according to Garrote (left) (after Artíñano y de Galdácano 1920, 122, figure not numbered), and its interpretation (drawing by J. Casabán).

Garrote also described in his manuscript the traditional design method used in Spain during the 17th century to define the ship's master frame. This method was also based on the use of one circle to define both arcs of the midship section, and was the same design that Gaztañeta mentioned in his manuscript (Figure 48). This time,

[119] Artíñano y de Galdácano 1920, 340-1.

however, Garrote described how to use this method to design the molds (*galibos*) of the master frame.[120] In other words, Garrote explained how the dimensions provided by the different sets of 17th-century Ordinances were applied to define a ship's master frame.

According to Garrote, the mold of the master frame was designed with a depth of hold equal to half of the maximum breadth (1-2) (Figure 48). The ship's maximum breadth was located one cubit below the main deck (3-4) (Figure 48), as in the midship section represented in Gaztañeta's manuscript, in order to maintain the main deck or gundeck sufficiently high above the water.[121] In Garrote's opinion, this design was appropriate only for a vessel that stayed in port, but not suitable for a ship to set sail fully laden up to its maximum breadth level (1-2) (Figure 48) because its tumblehome would force the ship to not keep a straight course. The same would occur even if the maximum breadth level was located well above the waterline, because with the wind the maximum breadth would become submerged in water and the ship would tend to drift leeward, making navigation difficult. Warships and merchant vessels bound for the Indies were the only ones that could keep a straight course because of situating their maximum breadths in between decks. However, these vessels were unable to effectively employ guns on the main deck, and had to be girdled (*embono*), even if only in the space between the wales, in order to heighten the location of the ship's maximum breadth.[122]

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[120] Artíñano y de Galdácano 1920, 122.
[121] Artíñano y de Galdácano 1920, 341.
[122] Artíñano y de Galdácano 1920, 342.

The recommended deadrise (*astilla muerta*) of the master frame was measured in inches (*pulgadas*), and equaled the ship's maximum breadth, although each cubit was converted as being equal to an inch.[123] The deadrise helped to prevent the drifting of the vessel and to direct the water towards the rudder. This effect, however, was not fully achieved due to the traditional design of the vessel's bottom, which was straight from the keel to the turn of the bilge (*puntos de escoa*). As a result, the ships tended to roll like a cask in the water, without any resistance. In order to alleviate this problem, Garrote proposed to reverse the design of the lower part of the ships floors as it was recommended in the Ordinances of 1666.[124]

[123] 1 cubit equals 24 *pulgadas*, therefore, if a ship had a breadth of 16 cubits, its deadrise then was set equal to 16 inches. Artíñano y de Galdácano 1920, 342.
[124] Artíñano y de Galdácano 1920, 342.

CHAPTER VI

THE DESIGN OF THE MASTER FRAME IN SPAIN: ARCHAEOLOGICAL EVIDENCE (15TH-16TH CENTURIES)

Introduction

The information provided by the analysis of the archaeological remains of Iberian ships is limited in relation to the design of the master frame. In many cases, the archaeological remains consist of the main floor and the lower ends of the futtocks. Additionally, the original shape of the timbers is usually distorted due to the site formation processes. However, there are also cases, such as the 24M ship at Red Bay, Labrador (Canada), and the Western Ledge Reef wreck in Bermuda, that have allowed the reconstruction of the design of the master frame based on archaeological evidence. However, only the reconstruction of wreck 24M at Red Bay is based on extensive hull remains, while the archaeological evidence used for the Western Ledge Reef wreck was limited to the main floor and the lower part of the futtocks.

The examination of the archaeological remains of a series of 15th- and 16th-century shipwrecks of Iberian origin provides information about the design development of the master frame (Table 41). The vessels used in this study are those grouped together by Oertling based on a series of eleven construction features that he documented in ships built in the Iberian Peninsula during the 15th and 16th centuries.[1] According to Oertling,

[1] Oertling 2004, 129.

this set of eleven characteristics defines a unique method of shipbuilding used on the Spanish and Portuguese Atlantic coast to build ships regardless of their types, function, and tonnage.[2]

Table 41. Iberian vessels.

WRECK	LOCATION	YEAR
Vessel A, Rye.	Sussex, England	16th century
24M vessel (*San Juan*), Red Bay.	Labrador, Canada	1565
San Esteban, 1554 Fleet at Padre Island.	Texas, USA	1554
Highborn Cay Wreck.	Bahamas	Early 16th century
Molasses Reef Wreck, Turks & Caicos.	B.W.I	Early 16th century
Cattewater Wreck.	Plymouth, England	1st half of 16th century
Studland Bay Wreck.	Poole, England	16th century (ca. 1525)
Emanuel Point Wreck at Pensacola Bay.	Florida, USA	1559
Western Ledge Reef Wreck.	Bermuda	Late 16th – Early 17th century
St. John's Bahamas Wreck.	B.W.I	ca. 1550-1575
Angra D, Azores Wreck.	Portugal	ca. 1600-1625
Nossa Senhora dos Mártires (Pepper Wreck).	Portugal	1606
Cais do Sodré Wreck.	Portugal	Late 15th - early 16th century
Corpo Santo Wreck.	Portugal	Late 14th century
Ria de Aveiro Wreck.	Portugal	Mid-15th century
San Diego.	Philippines	1600

The present analysis focuses on the examination of the archaeological features related to the design of the master frame of Iberian vessels, and their correlation with the information provided in contemporary shipbuilding treatises and manuscripts. These archaeological features include the number of master frames, and the shapes of the main floors and futtocks. The analysis also includes the galleon *San Diego* even though it was

[2] Oertling 2004, 133.

built in the Philippines rather than on the Iberian Peninsula. Nevertheless, *San Diego* was designed and built according to Ibero-Atlantic shipbuilding traditions (Table 41).[3]

The Iberian master frame: archaeological evidence

The amount of information related to the design of a particular ship's midship section varied from one wreck to another due to the different levels of preservation of archaeological remains (Table 42). For instance, the archaeological remains of the late 14th-century Corpo Santo wreck (Portugal), and *San Esteban*, one of the 1554 wrecks excavated off Padre Island (USA), included only their stern knees, without any trace of their midship sections.[4] The 16th-century Vessel A wreck (England), on the other hand, had its mast step and three floors preserved, although none of the floors were identified as the ship's main floor.[5] The master frame of the late 15th- or early 16th-century Cais do Sodre shipwreck (Portugal) was damaged by bulldozers and discarded before archaeologists could examine it.[6] Finally, the full extent of the preserved hull remains, including the floor and futtocks of the master frame, of the Saint John's shipwreck in the Bahamas (ca. 1550-1575) is unclear.[7]

The central portion of the hulls of the early 16th-century Molasses Reef wreck (Turks and Caicos) and the early 17th-century Pepper wreck (Portugal), on the other hand, were preserved, although their master frames were not. Nevertheless, the

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[3] Oertling (2004, 130) does not include the galleon *San Diego* in his list of Iberian ships.
[4] Alves et al. 2001a 405; Rosloff and Arnold 1984, 290-2.
[5] Lovegrove 1964, 115-22
[6] Castro et al. 2011, 337.
[7] Malcolm 1996, 41-4.

approximate positions of their master frames were determined based on indirect archaeological evidence. Their locations were based on the preservation of futtocks located forward and aft of the approximate location of the master frames, and the nail marks of the floors left on the hull planking, combined with shipbuilding information provided by Oliveira in the case of the Pepper wreck.[8]

Table 42. Preserved main floors and their number.

WRECK	YEAR	MAIN FLOOR	NUMBER
Vessel A, Rye.	16th century	Unknown	-
24M vessel (*San Juan*), Red Bay.	1565	YES	1
San Esteban, 1554 Fleet at Padre Island.	1554	NO	-
Highborn Cay wreck.	Early 16th century	YES	1
Molasses Reef wreck, Turks & Caicos.	Early 16th century	Not preserved (approximate location)	1
Cattewater wreck.	1st half of 16th century	YES (F20)	1
Studland Bay wreck.	16th century (ca. 1525)	YES (219)	1
Emanuel Point wreck at Pensacola Bay.	1559	YES	1
Western Ledge Reef wreck.	Late 16th – Early 17th century	YES	1
St. John's Bahamas wreck.	ca. 1550-1575	Not documented	-
Angra D Wreck.	ca. 1600 - 1625	YES (C101)	1
Nossa Senhora dos Mártires (Pepper Wreck).	1606	Not preserved (only nail holes)	3
Cais do Sodré Wreck.	Late 15th - early 16th century	Not preserved	1
Corpo Santo Wreck.	Late 14th century	Not preserved	-
Ria de Aveiro Wreck.	Mid-15th century	YES (Floor 1)	1
San Diego.	1600	YES (M121 and M122)	2

[8] Oertling 1989a, 232; Castro 2003, 14.

Number of master frames

The archaeological examination of Iberian wrecks with preserved remains of their midship sections also reveals different numbers and shapes of master frames. All of these vessels were theoretically Spanish- or Portuguese-built, although their nationality is uncertain in most cases, hence the reason why they are defined generally as Iberian (Table 42). Nevertheless, the analysis of the remains of their master frames may reveal a relationship between the number and shape of their midship sections, and their nationality according to contemporary treatises and manuscripts.

The Portuguese Fernando Oliveira indicated in his late 16th-century shipbuilding treatise that the number of master frames of a vessel varied from one to three depending on the length of the ship's keel.[9] In fact, this was one of the criteria used in the analysis of the hull remains of the Pepper wreck in order to determine the location and number of master frames, even though they had not been preserved.[10] The Spanish shipbuilding treatises, on the other hand, never mentioned the use of more than one master frame, irrespective of the ship's size. Therefore, the number of master frames observed on a shipwreck could be a useful criterion in determining if the ship was built in a Portuguese or Spanish shipyard or, at least, the national origin of its design concept. However, the opposite could also occur, when more than one master frame is identified in shipwrecks that had been tentatively identified as being Spanish or built in a Spanish shipyard, such as *San Diego*. It should be noted that only two of the wrecks examined in this study had

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[9] Oliveira 1991, 174.
[10] Castro 2003, 16.

more than one master frame based on either direct or indirect archaeological evidence (Table 42**).**

The Pepper wreck has been tentatively identified as the *nau Nossa Senhora dos Mártires*, which sank at the mouth of the Tagus River near Lisbon on September 15, 1606 while returning from India with a cargo of peppercorns.[11] According to Castro, the Pepper wreck was fitted with three master frames, although none of them were physically preserved in the archaeological record.[12] In fact, the only archaeological evidence related to the location of the three master frames were the nails holes for the frames observed on the hull planking. The number of master frames was also established based on the dimensions of the preserved portion of the Pepper wreck's hull when compared with the dimensions indicated in Oliveira's treatise.

According to Oliveira, ships with a keel length of 18 *rumos* (27.72 m) would have three master frames, and 18 pre-designed frames forward and aft of the master frames.[13] If the keel length ranged between 15 and 18 *rumos* (23.1 and 27.72 m), the ship would have two master frames, and for vessels with keels shorter than 11 *rumos* (16.94 m), one master frame was sufficient.[14] Castro also indicated that the rising and narrowing of the preserved floors of the Pepper wreck matched the dimensions provided in Olivera's *Livro da Fabrica das Naus* if the length of the main floor equaled 16 *palmos*

[11] *Nossa Senhora dos Martires* is the "most probable identification of the shipwreck" based on a search conducted in the National Museum of Archaeology database. Castro 2003, 6.
[12] Castro 2003, 14.
[13] Castro 2003, 16; Oliveira 1991, 174.
[14] Oliveira 1991, 174.

de goa (4.11 m).[15] The rest of the hull dimensions, including the keel length, were derived from this hypothetical floor length, following Oliveira's proportions.[16] In other words, the main hull dimensions published for the Pepper wreck were not based on the length of a main floor (which did not survive), but rather on calculations made by studying the rising and narrowing of the frames preserved in the hull. Nevertheless, the presence of more than one master frame in an Iberian shipwreck might indicate that it was built in a Portuguese shipyard or following a Portuguese design.

However, the Spanish galleon *San Diego*, which sank near Manila (Philippines) in 1600 during a battle against the Dutch pirate Olivier van Noort, also presents more than one master frame.[17] This ship was built in a shipyard in the Philippines,[18] although the shipbuilding contract providing its main dimensions has yet to be found, and therefore the preserved hull remains, including the lengths of hull and floors, cannot be compared with the original design dimensions.[19] Despite being built in an overseas Spanish shipyard, the vessel shows two distinctive main floors: M121 and M122. The number of frames matches that given by Oliveira, and additionally their location on the ships is closer to Oliveira's treatise than to Palacio's instructions since the frames are located two cubits forward from the center of the keel. In addition, both floors have futtocks attached to their outer sides. Floor M121 has two futtocks attached to the

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[15] Castro 2003, 16-7.
[16] Oliveira 1991, 165, 174.
[17] L'Hour 1996, 120-22, 147.
[18] L'Hour 1996, 120.
[19] L'Hour 1996, 149.

forward side towards the bow, while floor M122 has futtocks attached to the after side, in the direction of the stern.[20]

The reconstruction of the hull shape based on archaeological evidence shows a ship with a flat floor at the central part of the hull, which is in keeping with descriptions provided in 16th-century Portuguese and Spanish treatises.[21] However, it should be noted that this is a Spanish-built ship whose master-frame design presented similarities with the description provided by a Portuguese shipbuilding treatise. This could be related to the nationality and experience of the shipwright who built *San Diego* in the Philippines.

It should be noted that none of the Spanish shipbuilding treatises of the 16th and 17th centuries indicate the use of more than one master frame in their proposed designs. Moreover, Oliveira is the only Portuguese author who mentions the use of up to three master frames, since neither Fernandes nor Lavanha show more than one master frame in their designs.[22] These two shipwrecks are the only ones that reveal more than one master frame, while all the other examples examined during this analysis only exhibit one master frame.

The shape of the floors

In addition to the variation in the number of master frames observed in Iberian shipwrecks, there are also differences in the floor shape of the master frames. According

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[20] L'Hour 1996, 147.
[21] Oliveira 1991; Palacio 1944.
[22] Fernandes et al. 1995; Lavanha and Barker 1996.

to 16th-century Spanish shipbuilding treatises, and even in Oliveira's Portuguese treatise, the floors of the master frames should be flat without any deadrise, while the futtocks were to be defined by a single arc from the point marking the turn of the bilge or the end of the ship's flat (*punto de escoa*). Only Sarmiento's galleass design shows a curved or rounded master frame floor, the curvature of which is defined by an arc having a different radius than that of the futtock. The only shipbuilding treatise that presents a master frame design with curved floors is *Livro de Traças de Carpinteria* by the Portuguese Manuel Fernandes, dated to 1616. The archaeological examination of the evidence provided by Iberian vessels shows four cases in which the main floors are curved, and six cases in which they are flat. Additionally, in one case, there appears to be a straight floor with a slight angle, which may correspond to the deadrise of the flat (Table 43).

The shipwrecks with curved floors are Vessel A, although is unclear if the floor represented in the archaeological report corresponds to the master frame; the Cattewater Wreck (England); the Western Ledge Wreck (Bermuda); and the Ria de Aveiro A Wreck (Portugal). The chronology of these wrecks varies between the mid-15th century in the case of the Ria de Aveiro A Wreck, to the late 16th or early 17th century for the Western Ledge Reef Wreck (Table 43). Therefore, this type of design for the master frame appears to be used during the 16th century in both Spain and Portugal, even though the mention of the design only appears in Sarmiento's 1589 galleass design and in the early 17th-century Portuguese treatise by Fernandes.

Table 43. Main floor shape and deadrise.

WRECK	MAIN FLOOR	NUMBER	SHAPE	DEADRISE
Vessel A, Rye.	Unknown	-	Curved	-
24M vessel (*San Juan*) at Red Bay.	YES	1	Flat	NO
San Esteban, 1554 Fleet, Padre Island.	NO	-	-	-
Highborn Cay Wreck.	YES	1	Flat?	NO?
Molasses Reef Wreck, Turks & Caicos.	Not preserved (approximate location)	1	Flat?	NO?
Cattewater Wreck.	YES (F20)	1	Curved	YES
Studland Bay Wreck.	YES (219)	1	Flat?	NO?
Emanuel Point I Wreck, Pensacola Bay.	YES	1	Straight	YES (1 degree)
Western Ledge Reef Wreck.	YES	1	Curved	YES?
St. John's Bahamas Wreck.	Not documented	-	-	-
Angra D Wreck, Azores.	YES (C101)	1	-	YES?
Nossa Senhora dos Mártires (Pepper Wreck).	Not preserved (only nail holes)	3	Flat	NO
Cais do Sodré Wreck.	Not preserved	1	-	-
Corpo Santo Wreck.	Not preserved	-	-	-
Ria de Aveiro A Wreck.	YES (Floor 1)	1	Curved	YES?
San Diego.	YES (M121 and M122)	2	Flat?	NO

Interestingly, the tentative reconstructions of the master frames for the Cattewater and Western Ledge Reef shipwrecks have been based on an English 16th-century shipbuilding treatise, despite the fact that these wrecks have been classified as Iberian-Atlantic vessels.[23] However, it is doubtful that the Greek section illustrated in

[23] Friel 1984, 136; Bojakowski 2012, 300.

Baker's treatise was used in designing the master frames for these vessels, when the method is never described in any Iberian shipbuilding treatise. On the other hand, both Sarmiento and Fernandes provide examples of curved floors used in Iberian shipbuilding. Consequently, the master frame reconstructions of these two vessels could have been attempted based on Iberian shipbuilding treatises and documents.

Additionally, the floor curvatures of these two vessels also imply the presence of some deadrise in the flat of the master frame since the points marking the floor's length and the turn of the bilge (*puntos de escoa*) are also located higher with respect to the upper surface of the keel. These points are normally marked directly on the main floor timber, although no such marks were documented on the curved floors examined for this study. However, the examination of Sarmiento's design confirms the higher position of the turn of the bilge with respect to the upper surface of the keel (Figure 49).

The shipwrecks with flat and straight floors for the master frames are the 16th-century 24M wreck at Red Bay, Labrador (Canada), the Highborn Cay wreck (Bahamas), the Molasses Reef wreck (Turks and Caicos), the Studland Bay wreck (England), and *San Diego* (Philippines), and, theoretically, the Pepper wreck (Portugal). All of these vessels date from the early 16th to the early 17th century, and have been tentatively identified as of Iberian or Spanish origin except for the Pepper wreck, which may correspond to a Portuguese India *nau* (Table 43).[24] In addition, *San Diego* and the

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[24] The 24M vessel at Red Bay has been tentatively identified as the whaler *San Juan*, built in the Basque region of Spain (Bernier and Grenier 2007, 4:307); the Highborn Cay shipwreck has been classified as an Iberian shipwreck from the Age of Exploration period (Oertling 1989b, 252); the Molasses Reef shipwreck is defined as an unknown Spanish vessel (Oertling 1989a, 229); and Thomsen has identified the

Pepper wreck show the distinctive extra number of master frames, which does not conform to the characteristics proposed in the 16th- and 17th-century Spanish shipbuilding treatises. In any case, both of these shipwrecks present flat floors without any deadrise (Table 43).

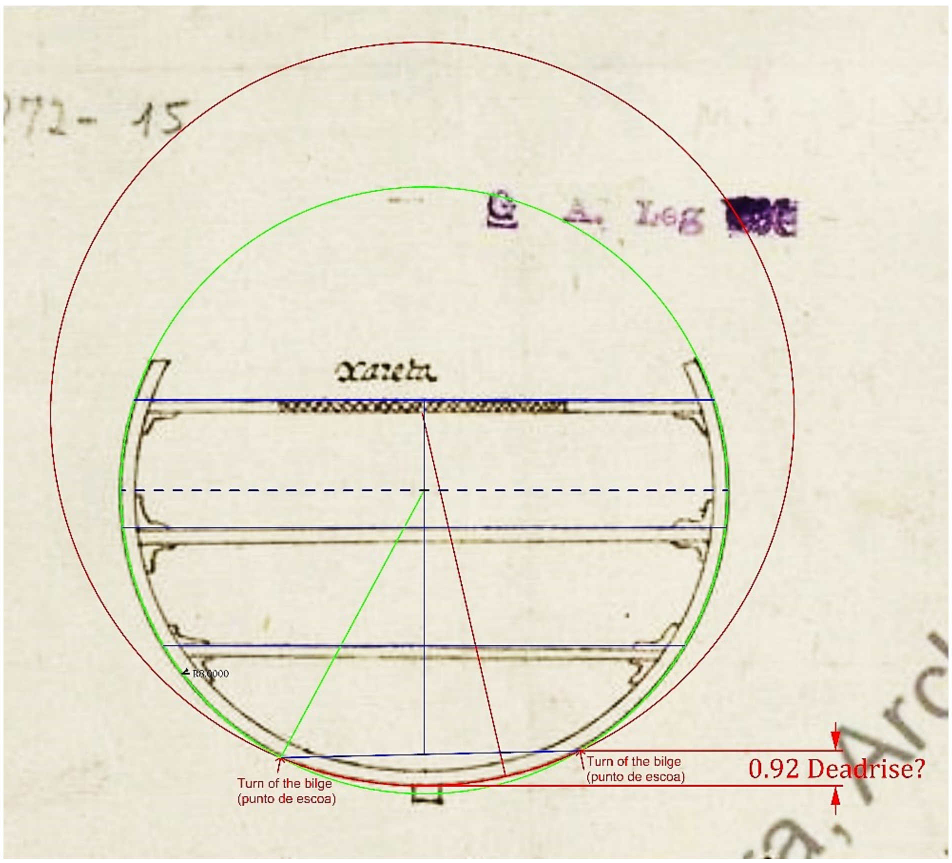

Figure 49. Sarmiento's midship section, showing the location of the turn of the bilge (*puntos de escoa*), and possible deadrise (modified after AGS MPD, 16, 165).

Studland Bay wreck as an Iberian vessel, probably built in the Basque region of Spain (Thomsen 2000, 81; L'Hour 1996, 120; Castro 2003, 6).

It should be noted, however, that shapes of the main floors of the Highborn Cay, Molasses Reef, Studland Bay, and *San Diego* wrecks are assumed to be flat based on the descriptions provided in the archaeological reports, since none of the reports provided section drawing of the floors (Table 43).[25] For instance, the main floor of the Molasses Reef wreck was not preserved, but its approximate location was determined according to the pattern of the futtocks fastened forward and aft of the theoretical location of the master frame.[26]

According to the archaeological evidence, the floor of the master frame of Iberian ships had two pairs of futtocks attached to either side of it instead of only a single pair fastened to only one side. The floors forward of the master frame had futtocks attached to the forward face of the floor, while the floors aft of the master frame had futtocks attached to their after face.[27] Therefore, the approximate location of the master frame of the main floor can be estimated by observing the changes in the orientation of the futtocks along the central section of the hull, normally underneath the mast step.

In those instances where the lower end of futtocks attached to the main floor are not preserved, the location of the main floor may be determined by the presence of dovetail mortises placed on both sides of a floor for attaching futtocks. These dovetail mortises were one of the construction characteristics that Oertling proposed as identifying features of Iberian-Atlantic vessels.[28] This characteristic was employed in

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[25] L'Hour 1996, 146-48.
[26] Oertling 1989a, 235-36.
[27] Oertling 2004, 129-30.
[28] Oertling 2004, 129-30.

identifying the location of the Catterwater wreck master frame, despite the fact that its futtocks were not preserved.[29]

Most recently, the Angra D shipwreck in the Azores has been dated to the first quarter of the 17th century, although an earlier study dated the sinking of the ship between the late 15th and early 16th centuries.[30] After excavating, cataloging, and studying the remains, frame no. 101 was tentatively identified as the ship's master frame.[31] The floor of the master frame presented a length between the dovetail mortises of 2.8 m. Unfortunately, no description about the floor's shape was provided, apart from a distortion noted along its port edge.[32] Initial study of the wreck's construction features, coupled with the initial early date, concluded that the ship's master frame was probably flat, as is typical for this period. On the other hand, if the later date for the wreck is confirmed, the shape of the floor would include a deadrise that would increase the height of the wrongheads with respect to the top of the keel, while also affecting the shape of the master frame (Table 43).

The main floor of the 24M wreck at Red Bay also provides relevant information about the configuration of the lower part of the master frame. Both ends of this floor show arrow marks, which defined the length of the floor and marked the turn of the bilge (Figure 50).[33] These points, known in Spanish as *puntos de escoa*, also marked the beginning of the arc of the futtock, which defined the side of the master frame. In

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[29] Redknap 1984, 26.
[30] Fraga and Bettencourt 2017, 446; Garcia and Monteiro 2001, 433.
[31] Fraga and Bettencourt 2017, 448; Garcia and Monteiro 2001, 433.
[32] Fraga and Bettencourt 2017, 448.
[33] Loewen 2007, 3: 87.

addition, the horizontal line defined between these points corresponded to the ship's flat, to which was applied the deadrise measured from the upper side of the keel.[34] Moreover, according to design reports, the ship's depth of hold was measured vertically from the flat (*plan*) to the main deck. However, in many cases, the vertical dimensions of the master frame, including the depth of hold and the height at which ship's maximum breadth was located, were measured from the ceiling planking (*granel*).[35] During the 17th century, these were the points at which the futtocks were tilted outward as determined by the value of the *joba*.[36]

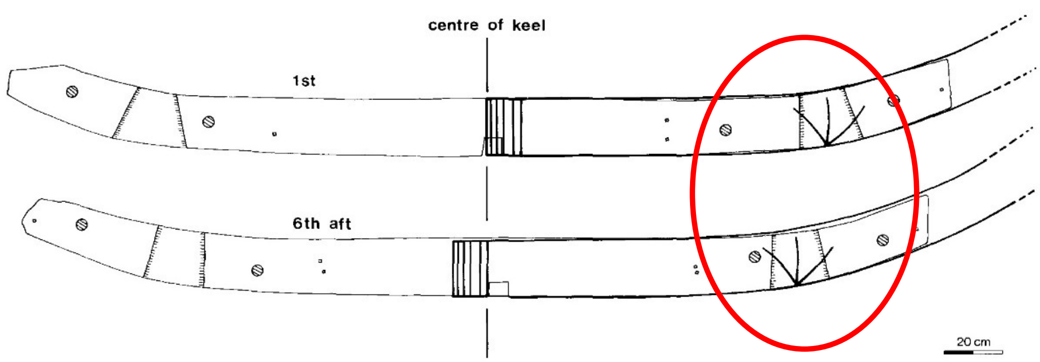

Figure 50. Arrows (right) on the central frames of the 24M vessel marking the turn of the bilge (*punto de escoa*) (after Loewen 2007, 3:96, figure 14.2.712).

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The final type of master frame floor shape is represented by the Emanuel Point I wreck. In this case, the floor is straight, with a deadrise of about one degree before the

[34] O'Scanlan 1831, 443.
[35] O'Scanlan 1831, 442.
[36] Gaztañeta et al. 1992, 1:31.

beginning of the turn of the bilge (Figure 51) (Table 43).[37] The presence of a deadrise in the Emanuel Point wreck floor represents an anomaly for this period since this feature is not specified in any Spanish shipbuilding treatise, manuscript, or ordinance until the 17th century, nor does it appear in the Portuguese treatise by Oliveira.

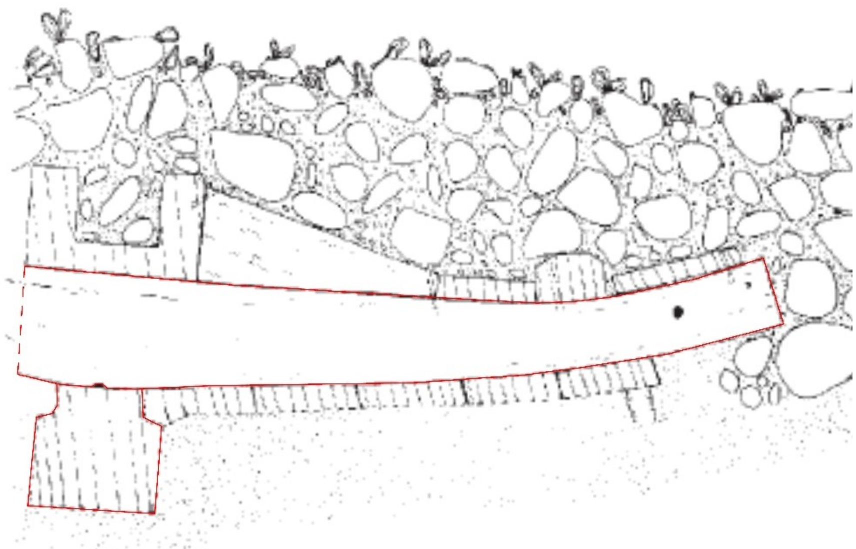

Figure 51. Midship section (port side) of the Emanuel Point wreck (after from Smith et al. 1995, 33, figure 15).

The master frame futtocks

In shipwreck hulls, the lower ends of the futtocks are usually preserved attached to the wrongheads of the main floors. Ideally, the shape of the futtocks may be used to reconstruct the section of the master frame, although often the results are limited by the short length of the preserved fragments. Six of the wrecks examined for this study had

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[37] Smith et al. 1995, 32-3.

some futtock remains still connected to the floors of the master frames, although in the case of the Cattewater wreck, the main floor was the only floor without preserved futtocks attached (Table 44).

Table 44. Master Frame futtocks.

WRECK	MAIN FLOOR	NUMBER	SHAPE	DEADRISE	FUTTOCKS
Vessel A, Rye.	Unknown	-	Curved	-	YES
24M vessel (*San Juan*), Red Bay.	YES	1	Flat	NO	YES
San Esteban, 1554 Fleet, Padre Island.	NO	-	-	-	-
Highborn Cay Wreck.	YES	1	Flat?	NO?	YES
Molasses Reef Wreck, Turks & Caicos.	Not preserved (approximate location known)	1	Flat?	NO?	
Cattewater Wreck.	YES (F20)	1	Curved	YES	YES (not the master frame)
Studland Bay Wreck.	YES (219)	1	Flat?	NO?	UNCLEAR
Emanuel Point I Wreck, Pensacola Bay.	YES	1	Straight	YES (1 degree)	UNCLEAR
Western Ledge Reef Wreck.	YES	1	Curved	YES?	YES
St. John's Bahamas Wreck.	Not documented	-	-	-	-
Angra D, Azores Wreck.	YES (C101)	1	-	YES?	YES
Nossa Senhora dos Mártires (Pepper Wreck).	Not preserved (only nail holes)	3	Flat	NO	NO
Cais do Sodré Wreck.	Not preserved	1	-	-	-
Corpo Santo Wreck.	Not preserved	-	-	-	-
Ria de Aveiro Wreck.	YES (Floor 1)	1	Curved	YES?	Not preserved
San Diego.	YES (M121 and M122)	2	Flat?	NO	YES

In only one instance, the 24M wreck at Red Bay, was it possible to reconstruct the entire shape of the section of the master frame due to the extent of the preserved length of the futtocks. This case, however, is an exception since typically futtock preservation is incomplete, and thus prevents a reliable reconstruction of its arc. Nevertheless, reconstruction of the master frame sections of the Western Ledge Reef wreck and the Cattewater wreck have been attempted with varying levels of success and accuracy.

The design of the master frame based on archaeological evidence

Despite the different levels of preservation of the Iberian shipwrecks, total or partial reconstructions of both master frame and hull shape have been attempted on several occasions. Despite these vessels being Spanish- or Portuguese-built, the majority of the reconstructions have been based on 16th- and 17th-century Portuguese shipbuilding treatises such as those by Oliveira, Fernandes, and Lavanha, and also on English manuscripts by Baker or even Dean. In fact, Palacio's treatise was the only Spanish document used in the theoretical reconstruction of the hull dimensions of the Emanuel Point and the Highborn Cay wrecks (Table 45).[38]

The reconstruction of *San Esteban*, one of the Padre Island wrecks, combined three different treatises to estimate the dimensions and shape of its hull. Ultimately, its reconstruction depended heavily upon the dimensions of the preserved heel timber.[39] On the other hand, the reconstructions of the Pepper wreck and *San Diego,* both of which presented more than one master frame (at least in theory in the case of the Pepper

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[38] Oertling 1989b, 250; Smith et al. 1995, 48.
[39] Doran and Doran 1978, 375-84; Rosloff and Arnold 1984, 295.

wreck), were performed relying on Oliveira's Portuguese treatise, despite *San Diego* probably being a Spanish-built vessel (Table 45).[40] The Portuguese treatises of Oliveira and Fernandes were used for the tentative reconstruction of the hull shape of the Studland Bay wreck, although the vessel has been tentatively identified as a Spanish-built vessel.[41]

Table 45. Reconstructed midship sections and treatises.

WRECK	MIDSHIP SECTION RECONSTRUCTION	TREATISES			
		SPANISH	PORTUGUESE	ENGLISH	OTHERS
Vessel A, Rye.	NO	-	-	-	-
24M vessel (*San Juan*), Red Bay.	YES	-	Fernandes 1616	Baker ca. 1570	
San Esteban, 1554 Fleet, Padre Island.	YES	-	-	Baker ca. 1570 Dean 1670	Pre Teodoro ca. 1550
Highborn Cay Wreck.	NO	Palacio 1587	-	-	-
Molasses Reef Wreck, Turks & Caicos.	NO	-	-	-	-
Cattewater Wreck.	YES	-	-	Baker ca. 1570	-
Studland Bay Wreck.	NO	-	Oliveira 1580 Fernandes 1616	-	-
Emanuel Point I Wreck, Pensacola Bay.	YES?	Palacio 1587	Oliveira 1580	-	-
Western Ledge Reef Wreck.	YES	-	-	Baker ca. 1570	-
St. John's Bahamas Wreck.	NO	-	-	-	-
Angra D, Azores Wreck.	NO	1613 Ordinances	-	-	-
Nossa Senhora dos Mártires (Pepper Wreck).	YES	-	Oliveira 1580 Lavanha ca. 1606-18 Fernandes 1616	-	-
Cais do Sodré Wreck.	NO	-	-	-	-
Corpo Santo Wreck.	NO	-	Lavanha ca. 1606-18	-	-
Ria de Aveiro Wreck.	NO	-	Oliveira 1580 Lavanha ca. 1606-18	-	-
San Diego.	YES	Palacio 1587	Oliveira 1580	-	-

40 Castro 2003, 16; L'Hour 1996, 146-47.
41 Thomsen 2000, 80-1.

Both the Western Ledge Reef and Cattewater wrecks were reconstructed using the curved floor design of the Greek section illustrated in Baker's English manuscript, ignoring the availability and applicability of treatises by Sarmiento and Fernandes.[42] Finally, the most successful and, in theory, accurate reconstruction of a 16th-century Iberian vessel is that of the 24M wreck at Red Bay. However, the reconstruction of its midship section was again based on Baker's manuscript, an English source (Table 45).[43] Therefore, the re-examination of several of these reconstructions using Spanish shipbuilding treatises or manuscripts can offer a different point of view when attempting future studies of 16th-century midship sections of Iberian vessels.

The Cattewater Wreck

Although archaeological and historical evidence has tentatively identified the Cattewater wreck as a 200-300 ton Iberian vessel, possibly Portuguese, which sank in the first half of the 16th century, the reconstruction of its master frame was based on the designs provided in an English shipbuilding manuscript "Fragments of Ancient English Shipwrighty," dated between 1570 and 1630, written by Mathew Baker and completed after his death by John Wells.[44]

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[42] Bojakowski 2012, 300; Friel 1984, 136.
[43] Loewen 2007, 3:258-62.
[44] Friel 1984, 136; Barker 1986, 161-63.

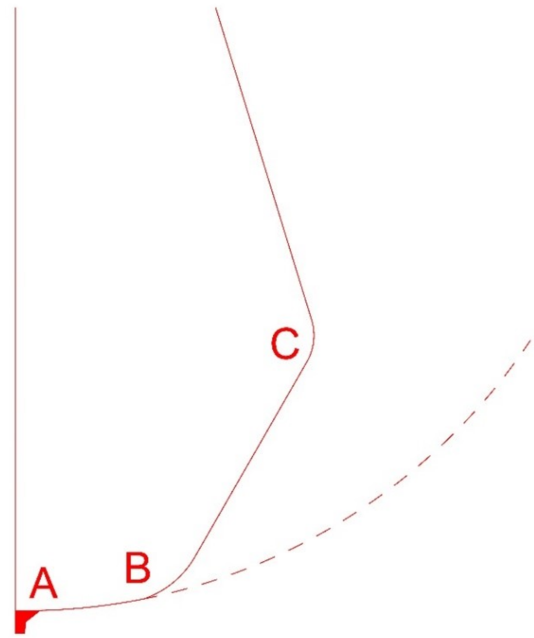

Figure 52. Half midship section of the Cattewater wreck based on Baker's Greek mould (after Friel 1984, 138, figure 60.b).

According to Friel, the majority of midship sections presented in Baker's manuscript show flat floors. Their shape is formed with three arcs, in which the third arc joins with the line of the top timber to form the ship's tumblehome.[45] The only midship section with a curved floor corresponds to an isolated example called the "Greek mould." This mould is for a type of Greek merchant ship called "screatse."[46] In this case, the midship section is composed of four curves, with the center of the first arc located along the central axis of the midship section; therefore, the initial deadrise of the floor is provided with the second arc (section A-B). However, the third arc has such a large

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[45] Friel 1984, 136.
[46] Figure 12 in *Fragments of Ancient English Shipwrighty*. Friel, 1984, 136.

radius that the arc becomes almost linear (section B-C). As a result of this situation, the joining of the third arc with the line defined by the top timber produces a sharp angle resulting in an unrealistic profile for the midship section (Figure 52).[47]

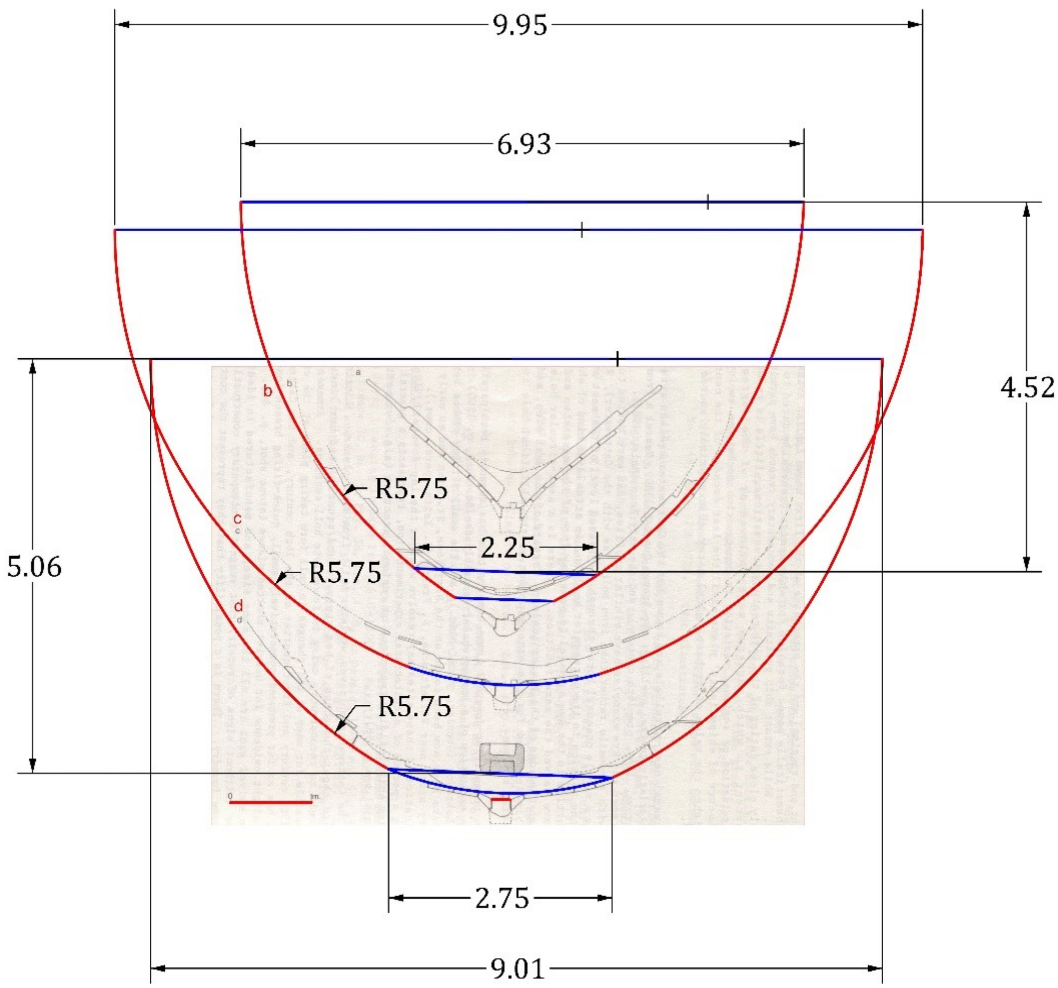

Figure 53. Reconstruction of the Cattewater ship's frames based on Sarmiento's methods. Units given in meters (modified from Redknap 1984, 96, figure 52).

[47] Friel 1984, 136.

In any case, Friel indicated in his tentative reconstruction of the Cattewater wreck that the maximum breadth of the vessel must have been less than 31.5 feet (9.6 m or 16.70 cubits), smaller than the radius calculated from the archaeological remains based on Baker's manuscript.[48] It should be noted that this reconstruction of the midship section of the Cattewater wreck is based on four restored frames of the vessel, none of which correspond to the master frame since only its main floor was preserved. Moreover, these frames consisted only of floors and the lower ends of the corresponding futtocks.

On the other hand, it is possible to apply an alternative design method to the reconstruction of the preserved sections of the Cattewater wreck based on the midship section of Sarmiento's galleass.[49] This design is based on a single arc to define the curvature of the main floor, which includes a deadrise (Figure 53). However, in this case, either side of the frames would be defined by an arc having same radius but different centers, while in Sarmiento's master frame design, the sides are defined by arcs having the same radius and centers. Basically, it would apply the same design principle used in Spanish vessels during the 16th and 17th centuries, in which either side of the master frame is defined with a single arc. According to this design method, the approximate maximum breadth of the Cattewater wreck would become around 9.01 m, and its depth of hold about 5.06 m. The resulting depth of hold-to-breadth ratio would be 0.56:1, similar to the traditional 0.6:1 depth of hold-to-breadth ratios used in Spanish

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[48] Friel 1984, 137-38.
[49] AGS MPD, 16, 165.

shipbuilding during the second half of the 16th century. These calculated values conform well with the measured Cattewater wreck remains, and support the view that this ship was built based on Iberian traditions and treatises, rather than the techniques described in Baker's manuscript.

Western Ledge Reef Wreck

Another example of an Iberian wreck whose master frame design has been correlated with the "Greek mould" of Mathew Baker and the Portuguese "oval frame" of Manuel Fernandes is the Western Ledge Reef wreck.[50] This wreck is of a small Spanish-built vessel that sank off Bermuda in the late 16th or early 17th century.[51] The hull remains of the wreck included 14 floor timbers, eight of them showing the characteristic dovetail mortises, and 21 lower ends of the first futtocks.[52] The master frame was identified thanks to the presence of four of these dovetail mortises on both faces of the main floor, two facing forward and two facing aft.[53] All the floors, including the main floor, were curved. According to Bojakowski, the length of floor of the master frame was defined by a horizontal distance between the inboard walls of the dovetail scarfs. These locations corresponded to the turn of the bilge on either side of the ship. The shape of the main floor followed the curvature of a single large arc designated as the "floor arc."[54]

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[50] Bojakowski 2011, 31.
[51] Bojakowski 2011, 18.
[52] Bojakowski 2011, 23.
[53] Bojakowski 2011, 29.
[54] Bojakowski 2011, 31.

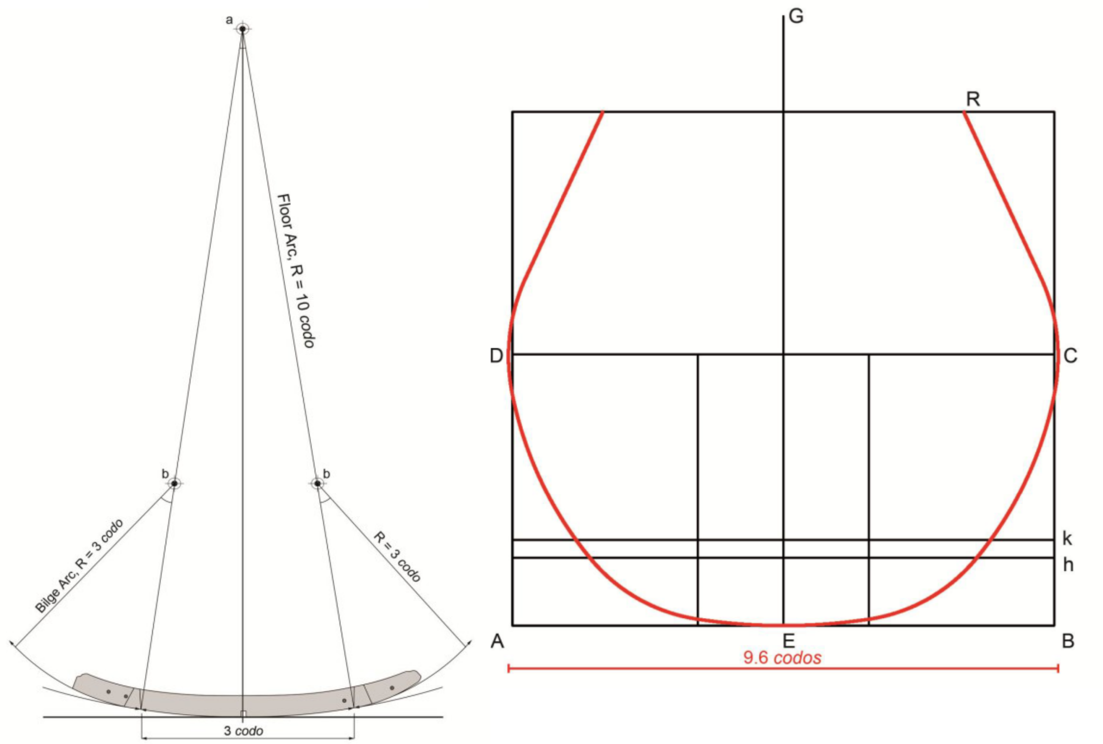

Figure 54. Preserved master floor and measurements (left) (after Bojakowski 2012, 282. Figure 5.8), and hypothetical master frame of the Western Ledge Reef wreck (right) (after Bojakowski 2012, 306. Figure 5.19).

The surviving master frame consisted of a complete curved floor and four deteriorated lower ends of the forward and after first futtocks. The section showed a single floor arc with a 10-cubit (5.75 m) radius. In addition, the floor length, or the horizontal distance between the "surmarks" (*puntos de escoa*), was three cubits (1.72 m). From these points the curvature of the wrongheads, together with the overlapping lower ends of the futtocks, had a three cubit radius (1.72 m). This arc was tangent to the arc of the floor timber, and remained constant. According to the analysis conducted, for every cubit of the bilge arc there were 3 1/3 *codos* of the large floor arc (1.92 m). The archaeological evidence also allowed determination of the precise location of the center of the respective arcs.[55] The master frame was reconstructed using Baker's "Greek mould", as in the case of Cattewater shipwreck reconstruction (Figure 54).[56]

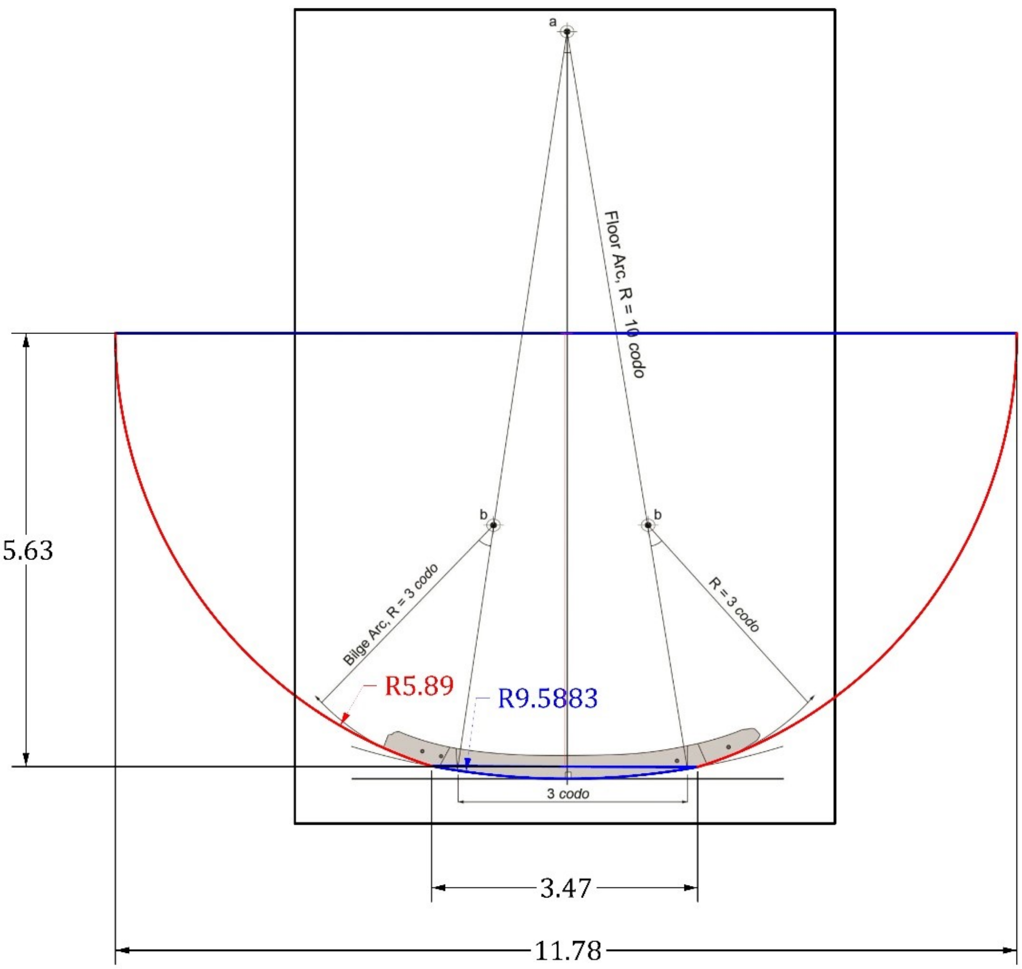

Figure 55. Reconstruction of the Western Ledge Reef wreck midship section based on Sarmiento's method (1589). Units given in cubits (1 cubit = 0.575 m) (modified from Bojakowski 2012, 282. Figure 5.8).

[55] Bojakowski 2012, 211-12. Figure 5.8.
[56] Bojakowski 2012, 300-6. Figure 5.19.

However, Sarmiento's design method appears to provide a second plausible method to graphically calculate the curvature of the main floor and lower ends of the futtocks, in order to reconstruct the midship section of the Western Ledge Reef wreck. An alternative design can be applied using two circles, as in the case of Sarmiento's galleass midship section, to produce a section with similar dimensions to those obtained using Baker's "Greek mould" method. A large, centrally placed circle would define the main floor, while a smaller circle with its center also located along the central axis of the master frame would define either side of the master frame up to the level of its maximum breadth (Figure 55).

Table 46. Ratios comparison.

SOURCE	DOH/B	F/B
24M Vessel,m 1565	0.53:1	0.30:1
Palacio, 1587	0.47:1	0.33:1
Western Ledge Reef wreck (Greek mould)	0.70:1	0.31:1
Western Ledge Reef wreck (Sarmiento's midship section)	0.47:1	0.29:1

Analysis of the results of applying Sarmiento's method showed a lower depth of hold-to-breadth ratio than the ratio produced using Baker's "Greek mould" method, but a similar floor-to-breadth ratio.[57] In fact, the new ratios are similar to those of the 24M

[57] The depth of hold is measured from the ship's floor to the height of its maximum breadth, where the radius of the arc used to define the sides of the midship section is located.

vessel at Red Bay, and to Palacio's treatise. The new depth of hold-to-breadth ratio becomes 0.47:1 instead of 0.70:1, while the floor-to-breadth ratio is 0.29:1, similar to the previous one of 0.31:1. These ratios are also similar to those of the 24M vessel and to Palacio's treatise (Table 46). While this is only a theoretical exercise, Sarmiento's method does provide an alternative construction hypothesis for these shipwreck remains, based on the Spanish graphical representation of the use of a curved floor for a master frame, without relying on the examples given in Baker's manuscript.

24M vessel at Red Bay (Labrador, Canada)

The last example of an Iberian vessel whose master frame design was also reconstructed using one of the methods described in Baker's manuscript is the 24M vessel at Red Bay, Labrador (Canada). This shipwreck has been tentatively identified as the Basque whaler *San Juan* from Pasajes (Guipúzcoa, Spain), which sank in Red Bay Harbor, Labrador (Canada) in 1565, although this identification has not been confirmed.[58] The hull remains of the Red Bay wreck were found collapsed outward onto the seabed, although they still formed a coherent structure up to the level of the waterline. Moreover, the scattered and broken timbers of the hull allowed the reconstruction of the hull to the waterline with "a high level of confidence."[59]

The archaeological remains of the hull included the original floor timbers, the first futtocks still connected with the floors, the second futtocks overlapping with the

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[58] Bernier and Grenier 2007, 4:307.
[59] Loewen 2007, 3:2.

first futtocks, the third futtocks overlapping the ends of the second futtocks--although only broken fragments were found--and scattered fragments of some top timbers, which were found near the forecastle and the stern quarterdeck.[60] This vast amount of archaeological evidence makes the 24M wreck the best preserved 16th-century Iberian vessel ever discovered. According to Loewen's study of the hull remains and his subsequent reconstruction, the method used to design the ship's midship section was similar to those used in England, employing several arcs instead of a system based on using a single arc.

Main floor timber

The midship section of the 24M vessel shows an essentially flat floor timber, without deadrise, as appears in 16th-century Iberian shipbuilding treatises and manuscripts.[61] The main floor extended flat from the center line of the keel, one cubit (0.575 m) to either side, while its wrongheads were defined by a tangent arc with a radius of 4.5 *codos* (2.59 m), which formed the turn of the bilge.[62] The floor timber of the master frame also presented the characteristic dovetail mortises on both forward and after faces, while the remaining floors had these mortises only on the side facing away from the master frame.[63]

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[60] Loewen 2007, 3:53.
[61] Palacio 1944, 92v, 94r, 97r; Oliveira 1991,174.
[62] Loewen 2007, 3:85.
[63] Loewen 2007, 3:62.

According to Loewen, the location of the mortises of the central frames was closer to the turn of the bilge. This location could be reflecting the narrowing of the frames produced by the half-moon (*mezzaluna*) method, although their alignment did not result in a fair curve as would be expected. Moreover, none of the 16th- and 17th-century shipbuilding treatises, manuscripts, and ordinances mention that the floor's mortises were located at the turn of the bilge.[64] In any case, Loewen is the first author to mention the possibility that the dovetail mortises of the floors could be marking the location of the turn of the bilge. A similar theory has now been proposed for the reconstruction of the Western Ledge Reef wreck's master frame; in this case, however, the inner edges of the dovetail mortises of the main floor are believed to define the floor length, and marked the turn of the bilge.[65]

In addition to the dovetail mortises, several floor timbers on the 24M wreck showed arrow-type marks at the turn of the bilge.[66] The arrow marks were located in the arcs that defined the floor's wrongheads, five centimeters above the keel, and their locations corresponded to the centers of the dovetail mortises. The horizontal distance between the arrows at both ends of the floor of the master frame was four cubits (2.3 m).[67] The master frame and the frames fore and aft of it up to the sixth frame were straight and had no rising, although the arrows marking the turn of the bilge were all located five centimeters above the keel.[68] The arrow marks all appeared on the side

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[64] Loewen 2007, 3:83.
[65] Bojakowski 2012, 281.
[66] Loewen 2007, 3:83.
[67] Loewen 2007, 3:85.
[68] Loewen 2007, 3:92.

facing the master frame; any possible arrows originally located on the faces away from the master frame would have been obliterated when the dovetail mortises were cut. According to Loewen, both the arrow marks and the dovetail mortises helped to control the shape of both sides of the floor timbers. Therefore, the arrow marks represented the design of the shipwrights, while the dovetail mortises showed the carpenters' work to assemble the frames.[69] Archaeological evidence seems to confirm a relationship between the locations of the arrow marks and dovetail mortises on the ships' floors, and the turn of the bilge.

Breadth

The reconstruction of the 24M vessel's master frame based on the archaeological evidence shows a maximum breadth of 13.16 cubits (7.56 m) instead of only 13 cubits (7.47 m) as specified it was probably specified in its shipbuilding contract. According to Loewen, the majority of Guipuzcoan shipbuilding contracts provided the ship's maximum breadth in whole numbers of cubits.[70] However, there were exceptions to this, such as the Apostles, whose final designs for the medium-sized and large ships included half cubits in the maximum breadth dimensions.[71] In Loewen's opinion, the design breadth of the 24M vessel was 13 cubits; he noted that the master frame as-built tended to be slightly wider than the official dimension assumed for the vessel. This widening of

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[69] Loewen 2007, 3:83.
[70] Loewen 2007, 3:91, 261.
[71] AGS GYM Leg. 245 doc. 11.

the ship's breadth appeared in illustrations in both Baker's and Fernandes's treatises, where the sides of the master frame extended beyond the distance between perpendiculars. Finally, for the 24M vessel, the height at which the maximum breadth was located was exactly seven cubits above the keel, indicating that this dimension was better determined than the breadth.[72]

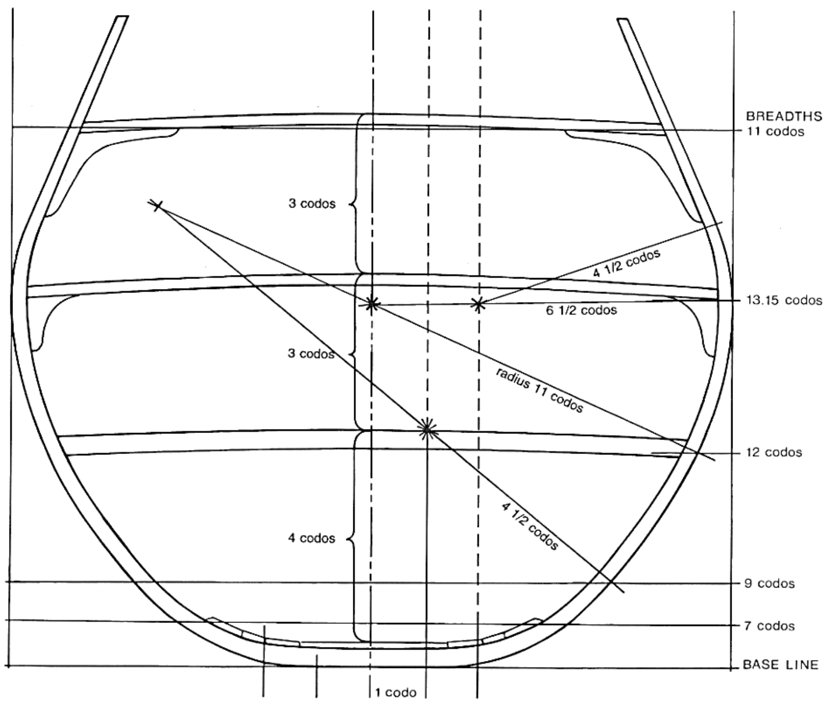

Figure 56. Design of the 24M vessel's midship section according to Loewen (after Loewen 2007, 3:92, figure 14.2.69).

[72] Loewen 2007, 3:91, 261.

Arcs of the master frame

According to Loewen, the midship section of the 24M vessel at Red Bay was formed by four consecutive arcs with different radii, the tangent straight floor, and tumblehome lines.[73] The 24M vessel had a two-cubit (1.15 m) straight horizontal floor, a bilge arc with a 4.5 cubit radius (2.59 m), a futtock arc with a 6.5 cubit radius (3.74 m), a tumblehome arc with a 4.5 cubit radius (2.59 m), and a straight tumblehome about four cubits long (2.3 m) (Figure 56).[74] The horizontal distances at which the intersections, or "touches," between two adjacent arcs were located seemed to be fixed, while their heights varied randomly (Figure 56).[75] According to Loewen, the design principles of the 24M master frame corresponded to the models represented in Baker's and Fernandes's shipbuilding manuscripts.[76] It should be noted that this design has no parallels in any Spanish shipbuilding treatises, manuscripts, or ordinances of the 16th and 17th centuries.

Analysis of the design of 24M vessel master frame

It is possible to re-examine the design proposed by Loewen for the 24M vessel's master frame in light of the information provided in 16th- and 17th-century Spanish shipbuilding treatises, manuscripts, and ordinances. For instance, the shape of the main floor and the absence of deadrise on the 24M vessel matches perfectly the description

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[73] Loewen 2007, 3:258.
[74] Loewen 2007, 3:91.
[75] Loewen 2007, 3:261-62; Loewen (2007, 3:5) defines the term "touch" as the intersection of two adjacent arcs.
[76] Loewen 2007, 3:91-2. Figure 14.2.69.

both Palacio and Oliveira provided in their treatises. The 24M wreck's midship shape supports the theory that the rising of the master frame was introduced sometime after the end of the 16th century (after the 24M ship was built), as all shipbuilding treatises, manuscripts, and ordinances seem to indicate.

In addition, the arrow marks observed on several floors of the 24M vessel, including the main floor, are what the 16th- and 17th-century Spanish shipbuilding contracts and ordinances referred to as "*puntos de escoa*." These points marked the length of the floor, one of the principal dimensions used in designing a ship's master frame, and also indicated the beginning of the arcs of the master frame. In the case of the 24M vessel, the length of the floor matched the typical 16th-century floor-to-breadth ratio of about 0.33:1.[77] These arrows also marked the point at which the arc of the futtock intersected with the floor of the vessel, indicating the beginning of the futtock. In the 17th century these points were the pivot points for adjusting the outward tilting angle of the futtocks depending on the *joba*. Deadrise was measured from the top of the keel; the horizontal line (*plan*), or floor length, was located at the level of the keel if no deadrise was applied. According to 16th-century treatises, the floor timber of the midship section had no deadrise. The central floors of the 24M vessel do not show any deadrise, but the arrow marks are located five centimeters above the keel. This height is too low to be considered a deadrise, and it is also less than the values recommended for the deadrise of the main floor in Spanish shipbuilding practices during the 17th century,

[77] Palacio 1944, 92v.; Cano and Dorta 1964, 62, 83, 102.

which varied between 0.5 cubits (0.29 m) and 1.25 cubits (0.72 m).[78] It should be noted that if these marks were situated at the same level as the upper side of the keel, the sharp angle of the turn of the bilge would make it quite difficult to fasten and caulk the planks at this part of the hull. Moreover, this height is similar to the thickness of hull planking below the first wale, which ranged between 5.5 and 6 centimeters.[79] Therefore, the height above the keel at which the arrow marks are located could be related to an attempt to fair the curve of the turn of the bilge, in order to facilitate the installation and caulking of the planking. In addition, during the 17th century, it was recommended to leave a bit of wood on the wrongheads before attaching the futtocks, in order to fair the turn of the bilge, producing a smooth transition between the floor timber and first futtock (Figure 57). This was related to the application of the *joba,* since the outward tilting of the futtocks on the arrow mark, or *punto de escoa*, determined the thickness of the wrongheads. Normally, all the floor timbers were shaped with the thickness of the floor of the tail frame whose futtocks showed the maximum angle with respect to the master frame that had no *joba*.[80]

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[78] Cano and Dorta 1964, 102-3; Boix 1841, 4:25.
[79] Loewen 2007, 3:109.
[80] Loewen 2007, 3:263; Gaztañeta et al. 1992, 1:32.

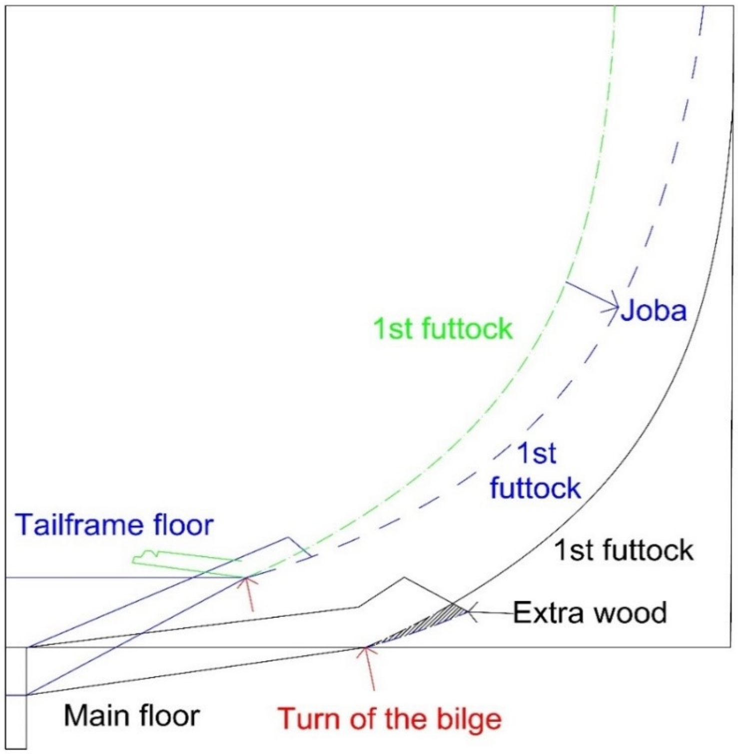

Figure 57. Fairing of the wrongheads (modified from Gaztañeta et al. 1992, 2:59, fol. 71, figure not numbered).

The ship's maximum breadth

One common issue for a 16th- or 17th-century Spanish vessel was the measurable difference between its theoretical design breadth, or contracted maximum breadth, and its actual as-constructed breadth. This variation was not the result of an intentional design concept, as described in the contemporary shipbuilding manuscripts and treatises cited by Loewen. In fact, this variation was an inadvertent consequence of the construction process. Constructed ships tended to have wider breadths than in their original designs because of their construction on soft ground in shipyards; the weight of the frame timbers spread the apart the shores supporting them before beams could be installed to lock the futtocks into place.[81] As Cristobal de Barros noted in the late-16th century, this widening of the breadth affected the ship's resulting tonnage and, more importantly, its draft. The problem was so well-known by the 17th century that shipbuilding ordinances included a clause stating the maximum variation of a ship's breadth could not exceed half a cubit (0.29 m) for a vessel contracted by the Crown.[82] Therefore, the variation of the 24M vessel's breadth that Loewen noted would not have been intentional, or even a design anomaly, but simply the inadvertent outcome of spreading caused by the weight of the futtocks while building the ship.

The shape of the master frame

Finally, there is also an alternative explanation to the concept proposed for the master frame of the 24M vessel, which was based on four arcs following the design principle illustrated by Baker and Fernandes. It should be noted that Loewen determined the configuration of the midship section by trial-and-error, using a 1:10 scale model of the reconstructed master frame.[83] However, this technique has no parallels in 16th- and 17th-century Spanish shipbuilding treatises, manuscripts, and ordinances. [84] According to these texts, the ship's master frame was designed with a single arc up to at least the height at which the ship's maximum breadth was measured. Despite Loewen's plausible

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[81] Navarrete 1971, 22.1, doc. 76, fols. 324-7.
[82] See *Sección* 18, Boix 1841, 4:25-6.
[83] Loewen 2007, 3:91-2.
[84] Loewen 2007, 3: 93.

interpretation, there is no reason to believe that the master frame of the 24M vessel was conceived in a different manner.

The midship section of the 24M vessel also presents a depth of hold-to-breadth ratio of only 0.53:1, almost equal to half of its maximum breadth, and similar to the ratios of 17th-century galleons, and those given in shipbuilding treatises and manuscripts. Moreover, the floor-to-breadth ratio of the 24M ship is 0.30:1, again similar to those of contemporary *naos* and galleons, and also to the proportion that Palacio, Escalante, and even the Portuguese Oliveira recommended in their treatises.[85]

Loewen also suggested that the horizontal distances between the intersections of the arcs were fixed, while their heights varied.[86] However, the only horizontal dimensions included in 16th- and 17th-century design reports, shipbuilding contracts, and ordinances were ship's breadth, floor length, and tumblehome. The height at which the ship's breadth was located was normally measured from the horizontal line between the "*puntos de escoa*" that defined the floor length. This line could be located at the level of the upper side of the keel or above the ceiling planking. The height at which the maximum ship's breadth was located, however, did not always correspond to the point from which the ship's depth of hold was measured. The only dimensions provided regarding the deck configuration of the vessels corresponded to the heights between decks, with no reference to any horizontal measurements. The last horizontal dimension

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[85] Palacio 1944, fol. 90-92v; Escalante 1985, 39-42; Oliveira 1991, 166, 185-86; Casado Soto 1988, 193, 199.
[86] Loewen 2007, 3:261-62.

of the master frame included in contemporary documents was the tumblehome. This was expressed as a reduction to the ship's maximum breadth to be applied on either side of the master frame. It could be measured at the level of the upper deck or at top of the bulwarks. No other horizontal or vertical dimensions were used in designing the master frame of ships built in Spain during this period. Thus, Loewen's suggested construction for the midship section of the 24M vessel is less likely based on documentary evidence.

Finally, it is possible to produce an alternative reconstruction of the midship section for the 24M vessel using the dimensions Loewen provided in his study, and the design method described in contemporary Spanish shipbuilding treatises. The master frame of this vessel can be reconstructed using a single arc for either side of the midship section defined from the end of the floor length or "*punto de escoa*" and the ships maximum breadth (Figure 58).

When the resulting section is overlapped with Loewen's model, the differences are minimal, and located at the lower part of the master frame, in the area of the wrongheads, with an offset of only five centimeters (0.09 cubits).[87] This difference could easily be attributed to the distortion of timbers that were flattened on the seabed for 400 years; despite their excellent preservation, this distortion may be explained by the weight of the wood itself, the weight of accumulated sediments covering them, and the site formation processes. In other words, the 24M ship's master frame can be easily

[87] The model of the master frame of the 24M vessel that has been published (Loewen 2007, 3:92) presents some distortions with respect to the measurements cited in the text such as the maximum breadth and depth of hold. Moreover, the midship section is not completely symmetrical as it can be observed in Figure 58. These discrepancies are probably due to publishing issues. Nevertheless, these issues do not affect the application and results of alternative design method proposed in this study.

reconstructed using contemporaneous Spanish design methods, with excellent results, without having to resort to a method based on English and Portuguese treatises, as proposed by Loewen.

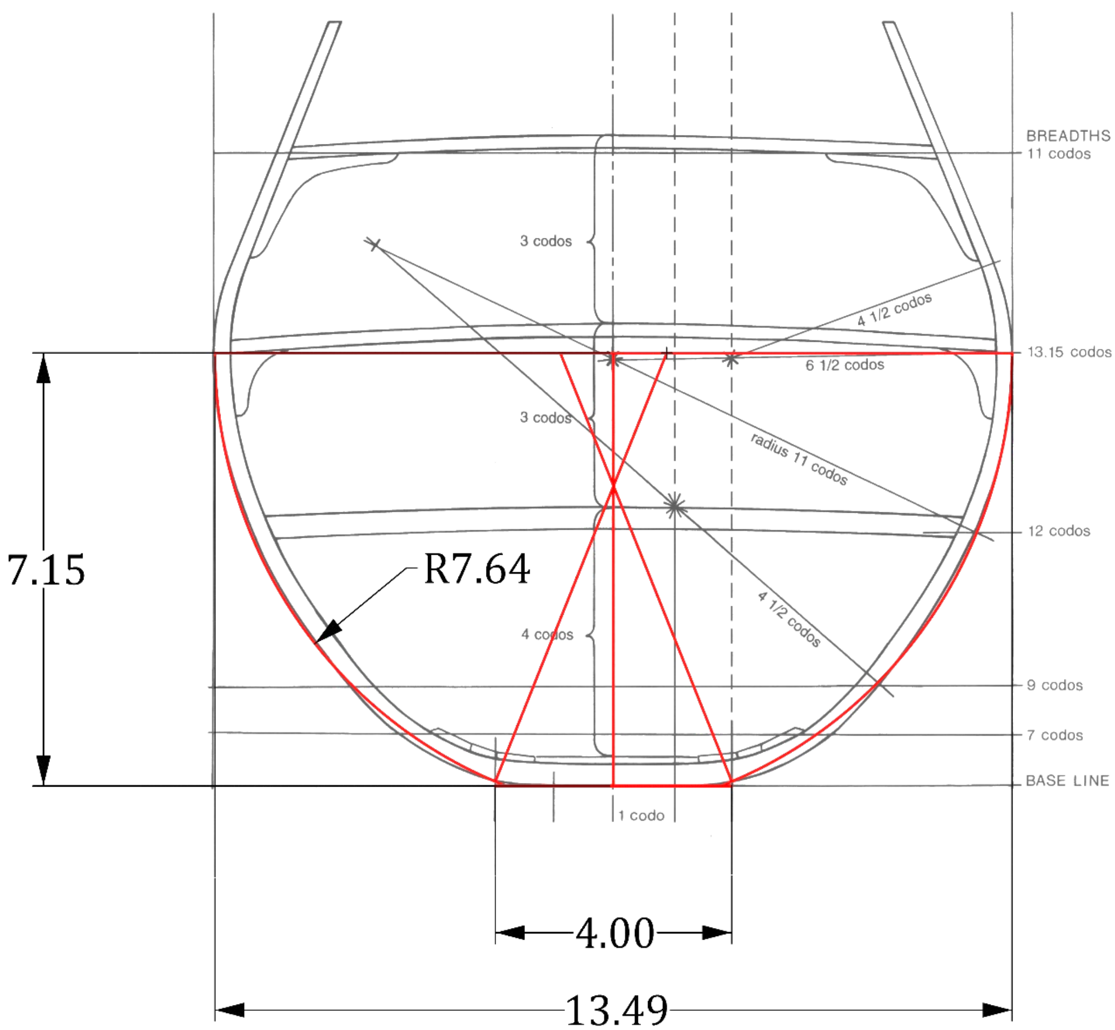

Figure 58. Alternative reconstruction of the 24M vessel's midship section based on a single arc. Units are given in cubits (1 cubit = 0.575 m (modified from Loewen 2007, 3:92, figure 14.2.69).

CHAPTER VII

CONCLUSIONS

The origin of the Spanish galleon and concluding remarks

The development of the Spanish galleon as a specialized warship took place in during the 16th century. A series of prototypes built in Spain in that century incorporated concepts and technological solutions from both the Mediterranean and the Atlantic maritime traditions, and became the basis for this new type of vessel. The objective was to develop a vessel that combined the oceangoing capabilities of the Cantabrian *nao* (ship) with the speed and maneuverability of the caravel and the Mediterranean galley. In fact, the first models were built according to a new type of design described as "galley-like" (*agalerados*), which reflected the original conception of the vessels. They were longer and narrower than contemporary sailing merchant vessels to favor speed but were also able to be rowed to enhance their mobility in any sea condition. However, the design and sailing capabilities of these new vessels did not facilitate the use of oars, and this hybrid concept was gradually abandoned.

The galleon was designed in response to changes in Atlantic trade routes at the beginning of the 16th century when, as a result of Spanish transoceanic expansion, new and more specialized vessels were needed for both the coastal defense of Spain and its overseas territories, as well as to escort the oceanic fleets. In other words, the Spanish galleon was the technological response to the new naval and commercial needs of the Spanish Empire that arose from the formation of its first permanent interoceanic system from Asia to Europe via the New World. Moreover, the development of the Spanish galleon would not have been possible without a well-established maritime culture and the technological capability to design, build, and operate this new type of vessel.

The importance and value of Spanish maritime culture has been traditionally under-researched, or simply downplayed, based on hypotheses developed primarily to explain the failure of the invasion of England by the Spanish Armada in 1588. However, all of the Spanish-built oceangoing galleons that participated in the expedition to England returned safely to Spanish ports, even after engaging English ships and encountering severe storms during their circumnavigation of the British Isles. Additionally, it has sometimes been erroneously stated that the failure of the Spanish Armada of 1588 marked the decline of Spain as a maritime power when, in fact, just the opposite had occurred. These inaccurate theories are based on interpreting the Spanish Armada according to modern concepts of naval warfare. Such interpretations will clearly have to be revised in future studies on 16^{th}-century Spanish ship design.

The only real consequence of the ill-fated Armada was the worsening of the chronic shortage of naval vessels that the Spanish Crown suffered during most of the 16^{th} century. As a result, King Philip II launched an ambitious shipbuilding program that led to the construction of 21 new galleons. This decision marked the beginning of the largest shipbuilding program attempted in Spain during the 16^{th} century. The Twelve Apostles were the first of these new galleons, built and launched in Spain between 1589 and 1591.

Traditionally, it has been emphasized that Spanish galleons were conceived as multipurpose vessels, to be used as either merchantmen or warships depending on the circumstances. This lack of specialized role made the Spanish galleons less effective as warships when compared to their English counterparts. However, the examination of the design of the galleons built for the Spanish Crown during the 16^{th} century reveals that they were specifically conceived as specialized warships adapted for transoceanic sailing conditions. It was not until the 17^{th} century when the design of galleons in Spain was shifted towards a multipurpose concept, due to the increasing demand for vessels to fulfill both defense and trade needs of the Spanish Empire.

The designs of the Twelve Apostles were the culmination of previous design series for building galleons and galleasses in Spain that began in 1540, when Álvaro de Bazán *el Viejo* (the Elder) built two large *galeazas* (galleasses) and two galleons for the coastal defense of Spain. Bazán's ships were followed by other series of galleons, which included the first Twelve Apostles built in 1567 by Menéndez de Avilés, the galleasses built by Barros in 1578, and the galleons built by Barros between 1582 and 1583, which took part in the Armada of 1588. The designs of each new series of galleons were an improved version of the previous ones in an attempt to correct any flaws observed once the ships became operational. During this period, it was impossible to evaluate or predict the seaworthiness of a vessel until it was launched and fully outfitted. The new Twelve Apostles built in 1589-1591 were no exception to this process, and their design incorporated elements of the previous models while trying to eliminate past flaws. In other words, the design of the Twelve Apostles was the result of nearly 50 years of Spanish naval construction lessons learned.

In addition, the design of the galleon as a warship during the second half of the 16th century, including the Twelve Apostles, was driven by the need to combine a shallow draft with a large capacity. All the design reports of this period focused on reducing the draft of the galleons in order to ensure that the ships could sail safely over Sanlúcar's sandbar at the mouth of the Guadalquivir River in Spain, and subsequently enter almost any shallow harbor in the Caribbean. The reduction of draft also related to the guns carried on the main deck. One of the main challenges in ship design during this period was ensuring that gunports of the main deck were located high enough above the waterline to allow their opening and the subsequent employment of ordnance in any weather or sea condition. Newly built ships tended to have deeper drafts than expected, and that could prevent the use of gunports near the waterline, as in the case of the galleons built by Barros. This was an issue discussed in almost every 16th-century Spanish design report, and it was an important consideration until the end of the 17th century. Unfortunately, the exact draft of a vessel could not be determined accurately until the ship was fully laden on the water, and by then it was too late to make modifications if the ship had a deeper draft than expected. One idea to prevent excessive draft was to increase the breadth of the vessel, by girdling the sides of the hull to provide additional strength. However, this solution made ships heavier and slower, and created structural problems for the hull. While this solution was employed at times to increase cargo capacity, it was ultimately forbidden in 17th-century Spanish ship design ordinances.

Moreover, the galleons had to be large enough to accommodate all the sailors and marines who comprised their crews. Initial designs such as Menéndez's galleons proved to be very effective vessels, but their limited internal volume made transoceanic journeys difficult because there was not enough space for the crew and the provisions that were needed for long journeys. This problem was addressed by increasing the size of the galleons, and dedicating the orlop deck to exclusively accommodate the crew and carry the provisions. This freed the main deck for ordnance, allowing the artillery to be used more efficiently. Therefore, the large capacity of the galleons designed as warships in Spain during the second half of the 16th century was actually more related to naval needs than for commercial purposes.

The design of the Twelve Apostles

Analysis of the design process of the Twelve Apostles shows a design system based on a committee of experts. This system began in the early 1580s and culminated in the 17th century with the introduction of a series of shipbuilding Ordinances developed by shipwrights, shipmasters, master carpenters, and naval commanders, which determined the basic design of Spanish oceangoing vessels for almost a century. In the case of the Twelve Apostles, a committee of experts was established to propose an optimal design for the vessels. The committee included shipwrights, shipmasters, master carpenters, and naval commanders, with their joint goal to agree on the best design specifications for the new galleons, taking into account their design as warships. This system, however, proved to be imperfect due to disagreements between Barros and the rest of the committee members about the dimensions of the galleons, although the system did ensure that the design of the galleons was supervised and agreed upon by a majority of experts.

The analysis of the documentation related to the design of the Twelve Apostles reveals how important it is to review all kind of documents prepared during this process, not just the final list of proposed dimensions and tonnages. Documents listing the main dimensions of a vessel are normally attached to letters whose authors provide a personal viewpoint about the reasons behind a particular design decision for a ship. Moreover, the information included in these letters is not only related to the design being discussed, but also to previous ships, including not only desirable qualities, but also any flaws observed after their construction. This is exactly what happened during the design of the Twelve Apostles, in which the correspondence between the King and the committee members reveals important information about the deep drafts of the galleass and galleons built by Barros more than ten years earlier. The same situation also occurred in relation to the correspondence related to the design process of the galleons built by Barros in the early 1580s, in which key information is provided about the design pros and cons of Menéndez *galeoncetes* that were built in 1567. This is an important issue to be considered when attempting to study the design, construction, and history of a particular vessel, or group of vessels, based on archival documents. Finally, the documents relative to the design of the Twelve Apostles also reveal ongoing struggles for the control of the design and construction process of the new vessels between the King's civil servants and the military commanders who would later operate the vessels.

The construction of the Twelve Apostles

Contemporary documents about the construction of the Twelve Apostles provide a realistic portrayal of the organizational requirements of a project of such magnitude in a pre-industrial society. There were many factors to be considered before starting the construction of 12 new vessels of the characteristics of the Twelve Apostles. In addition to the funding required to pay for the materials and the salaries of the workers, the choice of the shipyards to build the galleons could determine the success or failure of the project. The archival documentation reveals that the selection of a shipyard depended not only on the availability of nearby timber, manpower, and other raw materials such as iron, but also on the previous or current construction of other ships in the same area or facility. Despite the policies applied by the Spanish Crown to preserve and increase the forests of northern Spain to ensure the availability of timber for shipbuilding, high-quality wood was a limited resource that had to be managed carefully. Twelve large galleons could not be built in a single location because their construction would deplete the timber resources of the area for years, ultimately ruining the local economy. In addition, the construction of the galleons could not be carried out against the will of the local population, because a lack of local support increased the risk that the ships would never be completed. All these factors had to be examined carefully by the authorities while deciding the distribution of vessel building sites to ensure the success of the project. The combination of all these factor led to the ultimate distribution of the construction of the Twelve Apostles between two different shipyards, following the initial selection of three different construction locations.

The documentation regarding the construction of the Twelve Apostles also reveals the complexity of the logistics and the arrangements needed for the completion of the galleons. These arrangements included a wide range of issues, from the method to purchase timber from local owners of private forests, to the provision of food for the carpenters working in the shipyards. Everything was strictly regulated, although the chronic lack of funds that affected the construction of the Twelve Apostles led to opportunistic actions by the shipbuilders Ojeda and Riva Herrera in order to fulfill all of their construction needs.

The lack of money not only affected the purchase of raw materials and food, and the payment of the workers' wages, but also affected the importation of equipment needed to outfit the galleons. This was especially noticeable in relation to the ships' rigging and spars for the masts and yards, which had to be imported from the Baltic area. Although the highest quality rigging was produced in Spain, it was also both more expensive and took longer to make than rigging imported from northern Europe. Therefore, contracts were signed with Flemish merchants to provide rigging and masts. This was especially important in the case of the masts and yards due to the paucity of spars with adequate dimensions for the Twelve Apostles; delays in receiving this critical material delayed the construction of the galleons and became a logistical nightmare for the shipbuilders. The problem became so dire that a secret operation was planned to smuggle spars for the Twelve Apostles out of France on fishing vessels. The fact that many materials for the construction of the galleons had to be imported shows the complexity of the logistics to build the galleons and illustrates that their construction had an economic impact at an international level.

The large amount of documents related to the construction of the Twelve Apostles reflects the number of logistical issues that had to be solved in order to complete the vessels. The King personally monitored all the purchasing of the construction materials, and closely tracked the progress of the work. Both shipbuilders, Ojeda and Riva Herrera, dispatched letters to the King on a near-daily basis asking for money to continue the work, and informing him about the difficulties they had to overcome to build the ships. In addition to these letters, there were also numerous contracts, inventory lists, and other letters sent among the shipbuilders, Navy accountants and inspectors, and private merchants to ensure the delivery of the construction materials and to obtain the necessary funds to pay salaries and materials. Most of these documents are currently held in Spanish archives such as the General Archive of Simancas and the General Archive of Indies in Seville, providing a uniquely detailed view into the construction sequence of the Twelve Apostles and other series of galleons.

The conception of the Apostles

The information related to the design of the Twelve Apostles also shows how vessels were conceived during the 16th century. The documentation summarizing the meetings of the committee of experts in Santander reveals that only a limited number of dimensions were needed for the design of a new vessel. These dimensions included the maximum breadth, length, keel length, the height at which the ship's maximum breadth was measured from the ceiling planking, the heights between decks, and the tumblehome of the master frame as measured at the upper end of the bulwarks. The main dimensions of the upper works were not provided, although the design reports indicated that they had to be the same as those of the previous series of galleons built by Barros. In the same way, the bow and stern rakes of the Twelve Apostles had to follow the same proportions as the previous galleons. It should be noted that the main floor length was not provided in any document, but decided later in the shipyard by the master carpenters.

Despite the limited set of dimensions, this information was sufficient to calculate the internal volume of the vessel by applying a formula. Therefore, the dimensions agreed upon during the meeting corresponded to the internal dimensions of the vessels, and not the construction dimensions. For instance, there was no reference to the total depth of hold as measured from the upper surface of the keel, or even to the scantlings of the main hull components, such as the moulded and sided dimensions of the keel. All those measurements were to be decided later, based on the experience and expertise of the master carpenter in charge of the construction of the vessels. This is an important aspect that needs to be considered by researchers when attempting the reconstruction of a vessel based on archival documents, because these documents provide limited number of measurements. In order to ensure the accuracy of a theoretical reconstruction of a vessel, it is necessary to correlate this type of archival data with available archaeological evidence, although the latter is also always limited and incomplete. In other words, the archival documents related to the design of Spanish vessels of the second half of the 16^{th} and the 17^{th} century only provide the internal dimensions of the vessels; additional information must be collected to maximize reconstruction accuracy.

Additionally, the dimensions proposed in the design reports are theoretical, and rarely match the final dimensions of the as-built vessels. This situation is documented in the case of three of the Twelve Apostles that were surveyed in 1592 while moored in Portugalete. The dimensions surveyed included the ship's maximum breadth, the depth of hold, the height at which the ship's maximum breadth occurred as measured from the ceiling planking, and the ship's length measured at the same level as the maximum breadth. The surveyors measured these dimensions to calculate the ship's tonnage. However, the surveyors also measured the vertical distance between the upper surfaces of the keel and the ceiling planking. It should be noted that this distance ranged between 0.5 and 0.66 cubits (0.29 and 0.38 m) in all three galleons, and it included the moulded thickness of the floor and the ceiling planking. This vertical distance did not affect the calculation of the ship's tonnage, although it does indicate the differences between the dimensions used for the design of the vessel and the resulting dimensions in the finished vessels.

The issue of variations between the theoretical and actual dimensions of a vessel was known by the contemporary shipbuilders and master carpenters. These variations occurred for a range of reasons, such as the fact that vessels were built by eye instead of according to a set of construction plans. In addition, these variations also depended on the weight of the wood used for the construction of the ship, and the firmness of the ground in the shipyard. For instance, the weight of the futtocks caused the hulls to sink into the soft ground of the shipyard, spreading out the wooden shores that supported the sides of the frames, before the frames could be secured with deck beams. Therefore, the as-delivered breadth of the ship under construction tended to be wider than planned. Ships were surveyed after they were completed because the variations of their initial dimensions affected their volumes, which, in turn, determined the King's payments for the construction of the vessels.

Nevertheless, the differences between the approved dimensions and the final dimensions of a ship after its construction were a common problem from the 16th to the early 18th century. These discrepancies were due to the difficulties in transferring the original design specifications to the actual ship under construction. Although ships were the most advanced machines of their time, they were built within the context of a pre-industrial society, with limited technological resources. Technological factors such as materials, tools, and techniques of production did not always allow an accurate fulfillment of the original design. This is another important issue to be considered when attempting the reconstruction of any ship built during the pre-industrial period. Theoretical reconstructions of these vessels cannot be approached with modern-day standards of accuracy, especially when using CAD programs that display millimetric accuracy when producing a theoretical three-dimensional model. Despite the limitations of the era, 16th-century galleons were the most advanced constructions of their time; they were outstanding products whose final version depended on the manual expertise and craftsmanship of the carpenters who built them.

Finally, the analysis of the documents also reveals differences in the terminology used to define the deck configuration of vessels during the second half of the 16th century with respect to designs of the 17th century. Documents related to the design of the Twelve Apostles and the previous series of galleons, never refer to the upper deck as a deck, as they do in 17th-century shipbuilding ordinances. In fact, the upper deck is referred as a grating that become the upper deck of the galleons, with the ships' maximum breadth located one cubit above the main deck (*segunda cubierta*) and he upper deck (*jareta/puente*).

The function of the Twelve Apostles

The comparative analysis of the hull ratios of the Twelve Apostles with the previous series of galleons designed and built specifically as warships in Spain reveals that the Twelve Apostles' hulls were shorter and wider, but not deeper. Despite Cristóbal de Barros's concerns about the Twelve Apostles being designed as merchant vessels instead of warships, their length-to-breadth ratios were still higher than the expected traditional ratio of 3:1 defined by the 16th-century empirical *as-dos-tres* rule, which Barros indicated for merchant vessels. Moreover, their depth of hold equaled about 2/3 of their maximum breadths, similar to the ratios observed in all 16th-century designs for both merchant and naval vessels. Therefore, the main differences between the designs of the Twelve Apostles and earlier warships built during the second half of the 16th century were limited to the length of their hulls with respect to their maximum breadth.

The hull ratios of the Twelve Apostles were more conservative than those of the previous Spanish galleons of the second half of the 16th century. However, this conservatism of the hull proportions was probably an attempt to correct the flaws observed in the previous designs, which produced ships with deep drafts that constrained their performance as naval vessels. In fact, the length-to-breadth ratios of Menéndez and Barros's galleons of 3.47:1 and 3.52:1, respectively, do not appear again until the second third of the 17th century, after years of design testing, and when the ships' depths of hold had become less than half of their maximum breadths to overcome the deep-draft problem. Nevertheless, despite the relatively conservative hull ratios of the Twelve Apostles, they had slimmer hulls than specialized merchant vessels such as the 24M vessel at Red Bay, the majority of the merchant *naos* built on the northern coast of Spain, and even contemporary Mediterranean-built oceangoing warships, such as those of the Illyrian squadron. Finally, the length-to-breadth ratios of the Twelve Apostles were closer to those of multipurpose vessels described in contemporary Spanish treatises, such as those by Escalante and Palacio, than to previous warship or merchantmen designs.

Additionally, despite the changes introduced by the shipbuilding Ordinances at the beginning of the 17th century, the ships built in Spain during the first quarter of the 17th century had similar length-to-breadth ratios as that of the Twelve Apostles. In fact, the only noticeable difference between the Twelve Apostles' ratios and even earlier 16th-century warships-and early 17^{th}-century galleons is that the depth of hold of the latter equaled half of the ship's maximum breadth in an attempt to solve the deep draft issues observed in 16^{th}-century vessels. This reduction was probably related to the introduction of the *joba* in Spanish naval design, which increased the stability of the vessel, reducing its draft and need of ballast, while increasing the speed of the vessel.

Only during the second half of the 17^{th} century did the length-to-breadth ratios again become similar to the ratios of specialized warships of the second half of the 16^{th} century. However, the focus of the Spanish design during this period had shifted towards the construction of multipurpose vessels that could serve both as specialized warships and cargo vessels. This new approach was the result of the constant need for both warships and merchantmen experienced by the Spanish Crown during the 17th century. In fact, the shipbuilding Ordinances issued in the second half of the 17^{th} century seem to sanction the new hull ratios observed in shipbuilding contracts and ship surveys more than to introduce them anew. During this period, the length-to-breadth ratios of ships further increased, while their depth of hold-to-breadth ratios remained half of their maximum breadths or were slightly increased. Ultimately, the last galleons built in Spain at the end of the 17^{th} century again presented lower length-to-breadth ratios, comparable to those of ships built in the late 16^{th} and early 17^{th} centuries. However, these vessels had proportionally much shallower hulls than in the earlier examples.

The design of the master frame

The comparative analysis of 16th- and 17th-century Spanish designs and survey reports, shipbuilding treatises, manuscripts, ordinances, and shipbuilding contracts confirms that the design of the midship sections of the vessels of this period, including those of the Twelve Apostles, were based on the use of a single arc. Either side of the master frame was defined by a single arc from the points marking the turn of the bilge (*puntos de escoa*) to the level at which the ship's maximum breadth was located. Moreover, the shape of the master frame above the ship's maximum breadth was then defined by the tumblehome, measured at the level of the upper deck or at the top timbers. This design method was based on a small set of vertical and horizontal measurements, which included the ship's maximum breadth, the vertical height at which the ship's maximum breadth was located from the ceiling planking or the ship's main flat, the floor length, and the tumblehome. At the beginning of the 17th century, two more dimensions were incorporated into this set of measurements supporting Spanish shipbuilding: the deadrise (*astilla muerte*) of the flat of the master frame, and the *joba*, which determined the outward tilting of the futtocks forward and aft of the master frame. The analysis also reveals that the deadrise of the flat of the master frame was introduced in the 17th century in Spanish naval design to reduce the rolling of the hull produced by the extension of the main floor length that, in turn, was intended to reduce the ship's draft. One of the main design issues of the galleons built during the second half of the 16th century was precisely their deep draft caused by their narrow floors and excessive depth of hold.

In addition, Spanish written sources provide alternative interpretations for the reconstruction of the midship section of Iberian-built vessels based on the use of a single arc. It has to be noted that the major part of the published reconstructions of master frames are based on 16th- and 17th-century Portuguese shipbuilding treatises such as those by Oliveira, Fernández, and Lavanha, and on English manuscripts by Baker and Dean. Two reasons can be proposed to explain this situation. First, the information about the design of the master frame in the Spanish written sources, including shipbuilding treatises, manuscripts, and archival documents, is both limited, and characterized by a paucity of graphical representations. These texts consist mainly of lengthy discussions about the ideal dimensions of ships and their proportions, instead of describing actual construction methods. In comparison, the late 16th- and early 17th-century Portuguese shipbuilding treatises and manuscripts offer several descriptions and graphical representations of the methods used to determine the midship sections in Portugal. Secondly, the majority of the Portuguese shipbuilding treatises and manuscripts have been translated into English since the early 1990s, almost at the same time that reconstructions based on archaeological data were being published. It should be noted that the majority of the reconstructions were published by American and English researchers who also used Matthew Baker's manuscript to support their interpretations. That the majority of Spanish shipbuilding sources, including treatises and shipbuilding Ordinances, have not been translated into English is another explanation of their absence in many of these studies. Palacio's treatise is the one exception to this lack of availability in an English translation.

Finally, many of the reconstructions of midship sections of shipwrecks have been based on complex designs inspired by Baker's work, which include several arcs of different radii to define the shape of the master frame. These designs contrast with those based on a single arc, typical for ships built in Spanish shipyards during this period, which raises questions about the accuracy of some modern-day reconstructions. Additionally, these reconstructions also demonstrate a biased approach towards 16^{th}- and 17^{th}-century Spanish ship design based on modern naval engineering concepts. Spanish archival documents provide an alternative to the traditional and overcomplicated interpretations regarding the methods used to define the master frame of Iberian vessels, especially of Spanish-built vessels. Different reconstructions for the midship sections of these ships may be proposed based on the same archaeological data, by using the aforementioned Spanish methods for designing the master frame. Nevertheless, it will not be possible to be completely certain about the accuracy of these research models until a "Spanish" version of *Mary Rose* or *Vasa* is found and systematically studied.

REFERENCES

Primary sources

AGS GYM Leg. 244 doc. 30, Esteban de Chalar to Philip II, 25 January 1589, Rentería.

Leg. 244 doc. 37, Agustín de Ojeda to Philip II, 10 January, 1589, Santander.

Leg. 244 doc. 38, Agustín de Ojeda to Philip II, 17 January 1589, Bilbao.

Leg. 244 doc. 39, Agustín de Ojeda to Joan de Cardona, 29 January 1589, Bilbao.

Leg. 244 doc. 44, Duarte de Acuña to Philip II, 20 January 1589, Bilbao.

Leg. 244 doc. 70, *Pedro de Busturria, Relacion de los arboles y bergas que son menester para arbolar los doze galeones que sean de azer de nuebo*, 27 January 1589, Santander.

Leg. 244 doc. 71, Joan de Cardona to Philip II, 26 January 1589, Santander.

Leg. 244 doc. 74, Joan de Cardona to Philip II, 10 January 1589, Santander.

Leg. 244 doc. 85, Joan de Cardona to Philip II, 26 January 1589, Santander.

Leg. 244 doc. 87, Joan de Cardona to Cristóbal de Barros, 4 January 1589, Santander.

Leg. 244 doc. 88, Joan de Cardona to Cristóbal de Barros, 6 January 1589, Santander.

Leg. 244 doc. 92, Hernando de la Riva Herrera to Philip II, 9 January, 1589, Santander.

Leg. 244 doc. 217, Duarte de Acuña to Philip II, 31 January 1589, Bilbao.

Leg. 244 doc. 264, Cristóbal de Barros to Philip II, 20 January 1589, Santander.

Leg. 244 doc. 266, Cristóbal de Barros to Philip II, 8 January 1589, Santander.

Leg. 244 doc. 267, Philip II to Joan de Cardona, 22 November 1588, Madrid.

Leg. 244 doc. 268, Philip II to Cristóbal de Barros, 28 November 1588, Madrid.

Leg. 244 doc. 269, Cristóbal de Barros to Philip II, 31 January 1589, Santander.

Leg. 245 doc. 3, Joan de Cardona to Cristóbal de Barros, 5 February 1589, Santander.

Leg. 245 doc. 5, Joan de Cardona to Philip II, 10 February 1589, Santander.

Leg. 245 doc. 7, Joan de Cardona to Philip II, 24 February 1589, Santander.

Leg. 245 doc. 11, Joan de Cardona to Philip II, 4 February 1589.

Leg. 245 doc. 31, Hernando de la Riva Herrera to Philip II, 6 February 1589, Guarnizo.

Leg. 245 doc. 32, Hernando de la Riva Herrera to Philip II, 18 February 1589, Guarnizo.

Leg. 245 doc. 33, Hernando de la Riva Herrera to Philip II, 23 February 1589, Guarnizo.

Leg. 245 doc. 75, Agustín de Ojeda to Joan de Cardona, 10 February 1589, Bilbao.

Leg. 245 doc. 76, Agustín de Ojeda to Joan de Cardona, 16 February, 1589, Bilbao.

Leg. 245 doc. 88, Agustín de Ojeda to Philip II, 7 February 1589, Bilbao.

Leg. 246 doc. 2, Joan de Cardona to Philip II, 2 March 1589, Santander.

Leg. 246 doc. 5, Joan de Cardona to Philip II, 7 March 1589, Santander.

Leg. 246 doc. 15, Hernando de la Riva Herrera to Philip II, 12 March 1589, Guarnizo.

Leg. 246 doc. 90, Agustín de Ojeda to Philip II, 10 March 1589, Deusto.

Leg. 246 doc. 153, Duke of Medina Sidonia to Philip II, 8 March 1589, Sanlúcar de Barrameda.

Leg. 247 doc. 25, Hernando de la Riva Herrera to Philip II, 10 April 1589, Guarnizo.

Leg. 247 doc. 84, Agustín de Ojeda to Philip II, 4 April 1589, Deusto.

Leg. 247 doc. 85, Agustín de Ojeda to Philip II, 14 April 1589, Deusto.

Leg. 247 doc. 87, Francisco de Fuica to Philip II, 24 April 1589, Bilbao.

Leg. 248 doc. 7, Joan de Cardona to Philip II, 14 May 1589, Santander.

Leg. 248 doc. 26, Hernando de la Riva Herrera, 29 May 1589, Guarnizo.

Leg. 248 doc. 49, Duarte de Acuña to Philip II, 5 May 1589, Bilbao.

Leg. 248 doc. 50, Agustín de Ojeda to Philip II, 2 May 1589, Deusto.

Leg. 248 doc. 51, Agustín de Ojeda to Philip II, 19 May 1589, Deusto.

Leg. 249 doc. 16, Joan de Cardona too Philip II, 26 June 1589, Santander.

Leg. 249 doc. 51, Francisco de Fuica to Philip II, 6 June 1589, Bilbao.

Leg. 249 doc. 58, Agustín de Ojeda to Philip II, 6 June 1589, Deusto.

Leg. 249 doc. 59, Agustín de Ojeda to Philip II, 13 June 1589, Deusto.

Leg. 249 doc. 60, Baltasar de Lezama to Philip II, 20 June 1589, Bilbao.

Leg. 249 doc. 65, Gonzalo de Eraso to Philip II, 13 June 1589, Santander.

Leg. 249 doc. 259, Bernabé de Pedroso to Philip II, 27 June 1589, Santander.

Leg. 250 doc. 26, Alonso de Bazán to Philip II, 25 July, 1589, Santander.

Leg. 250 doc. 79, Agustín de Ojeda to Philip II, 11 July 1589, Deusto.

Leg. 250 doc. 80, Agustín de Ojeda to Philip II, 25 July 1589, Deusto.

Leg. 251 doc. 34, Agustín de Ojeda to Philip II, 5 September 1589, Deusto.

Leg. 251 doc. 35, Agustín de Ojeda to Philip II, 26 September 1589, Deusto.

Leg. 251 doc. 48, Hernando de la Riva Herrera to Philip II, 13 September 1589, Santander.

Leg. 251 doc. 49, Hernando de la Riva Herrera to Francisco de Arriola, 13 September 1589, Santander.

Leg. 251 doc. 54, Hernando de la Riva Herrera to Philip II, 27 September 1589, Santander.

Leg. 251 doc. 65, Luis de Fajardo to Philip II, 25 September 1589, Laredo.

Leg. 251 doc. 75, *Condestable* of Castile to Philip II, 7 September 1589, Barzo.

Leg. 251 doc. 76, Hernando de la Riva Herrera, 4 September 1589, Santander.

Leg. 251 doc. 77, *Condestable* of Castile to Philip II, 19 September 1589, Burgos.

Leg. 252 doc. 8, Francisco de Arriola to Philip II, 16 October 1589, San Sebastián.

Leg. 252 doc. 44, Agustín de Ojeda to Philip II, 3 October 1589, Deusto.

Leg. 252 doc. 49, Hernando de la Riva Herrera to Philip II, 13 October 1589, Santander.

Leg. 252 doc. 54, Martín de Bertendona to Philip II, 11 October 1589, Santander.

Leg. 253 doc. 34, Martín de Bertendona to Philip II, 17 November, 1589, Bilbao.

Leg. 253 doc. 35, Martín de Bertendona to Philip II, 21 November 1589, Bilbao.

Leg. 253 doc. 40, Agustín de Ojeda to Philip II, 28 November 1589, Deusto.

Leg. 253 doc. 44, Hernando de la Riva Herrera to Philip II, 10 November 1589, Santander.

Leg. 253 doc. 46, Hernando de la Riva Herrera to Philip II, 17 November 1589, Santander.

Leg. 253 doc. 54, Hernando de la Riva Herrera to Philip II, 22 November 1589, Guarnizo.

Leg. 253 doc. 55, Agustín de Ojeda to Hernando de la Riva Herrera, 18 November 1589, Deusto.

Leg. 253 doc. 57, Hernando de la Riva Herrera to Philip II, 28 November 1589, Santander.

Leg. 254 doc. 14, Agustín de Ojeda to Philip II, 1 December 1589, Deusto.

Leg. 254 doc. 15, Agustín de Ojeda to Philip II, 8 December 1589, Deusto.

Leg. 254 doc. 16, Agustín de Ojeda to Philip II, 12 December 1589, Deusto.

Leg. 254 doc. 18, Agustín de Ojeda to Philip II, 19 December 1589, Deusto.

Leg. 254 doc. 19, Agustín de Ojeda to Philip II, 31 December 1589, Deusto.

Leg. 254 doc. 22, Baltasar de Lezama to Philip II, 14 December 1589, Bilbao.

Leg. 254 doc. 52, Hernando de la Riva Herrera to Philip II, 15 December 1589, Santander.

Leg. 254 doc. 67, Juan de Soto to Philip II, 7 December 1589, Guarnizo.

Leg. 264 doc. 17, Philip II to Joan de Cardona, 10 January 1589, Madrid.

Leg. 264 doc. 18, *Las medidas de los 12 galeones que se han de azer*.

Leg. 264 doc. 19, *Relacion que dio Luis Cesar de las medidas y galibo que an de llevar los doçe galeones*, 10 January 1589, Lisbon.

Leg. 264 doc. 20, Álvaro Flores to Joan de Cardona, 10 January 1589.

Leg. 264 doc. 21, Cristóbal de Barros to Philip II, 31 December 1588, Santander.

Leg. 264 doc. 23, Philip II to Joan de Cardona, 17 February 1589, Madrid.

Leg. 264 doc. 24, Cristóbal de Barros to Joan de Cardona, 17 February 1589.

Leg. 265 doc. 22, *Relacion de la jarcia que ha venido a cuenta*, 16 October 1589.

Leg. 280 doc. 160, Hernando de la Riva Herrera to Philip II, 28 January 1590.

Leg. 280 doc. 206, Agustín de Ojeda to Philip II, 19 January 1590, Santander.

Leg. 281 doc. 46, Pedro Henríquez de Cisneros to Philip II, 6 February 1590, Santander.

Leg. 281 doc. 51, Juan de Soto to Philip II, 6 February 1590, Santander.

Leg. 281 doc. 52, Juan de Soto to Philip II, 12 February 1590, Guarnizo.

Leg. 281 doc. 75, Hernando de la Riva Herrera to Philip II, 5 February 1590, Santander.

Leg. 281 doc. 83, Hernando de la Riva Herrera to Philip II, 19 February 1590, Santander.

Leg. 281 doc. 85, Hernando de la Riva Herrera to Philip II, 28 February 1590, Santander.

Leg. 281 doc. 108, Agustín de Ojeda to Philip II, 9 February 1590, Deusto.

Leg. 281 doc. 109, Agustín de Ojeda to Philip II, 13 February 1590, Deusto.

Leg. 281 doc. 111, Agustín de Ojeda to Philip II, 20 February 1590, Deusto.

Leg. 281 doc. 112, Agustín de Ojeda to Philip II, 23 February 1590, Deusto.

Leg. 282 doc. 58, Agustín de Ojeda to Philip II, 23 March 1590, Deusto.

Leg. 282 doc. 59, Agustín de Ojeda to Philip II, 13 March 1590, Deusto.

Leg. 282 doc. 69, Hernando de la Riva Herrera to Philip II, 8 March 1590, Santander.

Leg. 282 doc. 73, Hernando de la Riva Herrera to Philip II, 23 March 1590, Guarnizo.

Leg. 283 doc. 29, Martín de Bertendona to Philip II, 27 April 1590, Bilbao.

Leg. 283 doc. 31, Agustín de Ojeda to Philip II, 11 April 1590, Deusto.

Leg. 283 doc. 45, Hernando de la Riva Herrera to Philip II, 2 April 1590, Santander.

Leg. 283 doc. 46, Hernando de la Riva Herrera to Philip II, 12 April 1590, Santander.

Leg. 284 doc. 19, Agustín de Ojeda to Philip II, 1 May 1590, Deusto.

Leg. 284 doc. 20, Agustín de Ojeda to Philip II, 8 May 1590, Deusto.

Leg. 284 doc. 22, Agustín de Ojeda to Philip II, 25 May 1590, Deusto.

Leg. 284 doc. 45, Hernando de la Riva Herrera to Philip II, 3 May 1590, Guarnizo.

Leg. 284 doc. 149, Esteban de Ibarra to Philip II, 25 May 1590, Lisbon.

Leg. 284 doc. 150, Esteban de Ibarra to Philip II, 19 May 1590, Lisbon.

Leg. 284 doc. 151, Esteban de Ibarra to Philip II, 19 May 1590, Lisbon.

Leg. 285 doc. 48, *Relacion de la arboladura que es menester para los 12 galeones*, 24 June 1590.

Leg. 285 doc. 49, Francisco de Arriola to Philip II, 24 June 1590, San Sebastián.

Leg. 285 doc. 50, Francisco de Arriola to Philip II, 24 June 1590, San Sebastián.

Leg. 285 doc. 51, Joan Veihagen to Francisco de Arriola, 22 June 1590, Bilbao.

Leg. 285 doc. 73, Agustín de Ojeda to Philip II, 5 June 1590, Deusto.

Leg. 285 doc. 155, Álvaro de Bazán to Philip II, 9 June 1590, El Ferrol.

Leg. 285 doc. 168, Bernabé de Pedroso to Philip II, 9 June 1590, El Ferrol.

Leg. 285 doc. 227, Esteban de Ibarra to Philip II, 2 June 1590, Lisbon.

Leg. 285 doc. 228, Esteban de Ibarra to Philip II, 9 June 1590, Lisbon.

Leg. 285 doc. 230, Esteban de Ibarra to Philip II, 16 June 1590, Lisbon.

Leg. 286 doc. 86, Bernabé de Pedroso to Philip II, 15 July 1590, El Ferrol.

Leg. 286 doc. 129, Esteban de Ibarra to Philip II, 9 July 1590, Lisbon.

Leg. 287 doc. 33, Agustín de Ojeda to Philip II, 14 August 1590, Deusto.

Leg. 287 doc. 34, Agustín de Ojeda to Philip II, 17 August 1590, Deusto.

Leg. 287 doc. 35, Agustín de Ojeda to Philip II, 28 August 1590, Deusto.

Leg. 287 doc. 57, Juan de Soto to Philip II, 13 August 1590, Santander.

Leg. 287 doc. 112, Álvaro de Bazán to Philip II, 27 August 1590, El Ferrol.

Leg. 287 doc. 175, Esteban de Ibarra to Philip II, 2 August 1590, Lisbon.

Leg. 287 doc. 182, Esteban de Ibarra to Philip II, 18 August 1590, Lisbon.

Leg. 287 doc. 183, Esteban de Ibarra to Philip II, 25 August 1590, Lisbon.

Leg. 288 doc. 36, Juan de Soto to Philip II, 5 September 1590, Santander.

Leg. 289 doc. 170, Duke of Medina Sidonia to Philip II, 31 October 1590, Sanlúcar de Barrameda.

Leg. 290 doc. 157, Agustín de Ojeda to Philip II, 20 November 1590, Deusto.

Leg. 290 doc. 158, Agustín de Ojeda to Philip II, 28 November 1590, Deusto.

Leg. 291 doc. 19, Esteban de Ibarra to Philip II, 15 December 1590, Lisbon.

Leg. 291 doc. 22, Esteban de Ibarra to Philip II, 22 December 1590, Lisbon.

Leg. 291 doc. 194, Duke of Medina Sidonia to Philip II, 16 December 1590, Sanlúcar de Barrameda.

Leg. 291 doc. 195, Duke of Medina Sidonia to Philip II, 21 December 1590, Sanlúcar de Barrameda.

Leg. 293 doc. 218, Philip II to Agustín de Ojeda, 12 March 1590, Madrid.

Leg. 299 doc. 137, *Paresçe al consejo que siendo Vmd servido podría hazer merced a los capitanes Pedro de Yvella y Estefano de Oliste de a cada mil ducados de ayuda de costa en tractas de Sicilia o Napoles*, 1 August 1590, Madrid.

Leg. 299 doc. 166, *Satisface el consejo a lo porque Vmd dexo de firmar una cedula de lso Yvellas por cuya parte se haze mucha instancia para que se les de la licencia que por ella piden*, 5 September 1590, Madrid.

Leg. 300 doc. 225, *Lo que parece al consejo cerca de lo que Don Alonso de Bazan ha escripto a Vmd para que los galeones nuevos de Vizvaya se traigan a Santande*r, 30 August 1590, Madrid.

Leg. 301 doc. 156, *Responde el consejo a lo que de parte de Vmd se le pregunto, del tiempo en que estaran prestos los doçe galeones nuevos y las naves que se podrian despedir de la armada para acudir a lo de las Indias*, 4 December 1590, Madrid.

Leg. 317 doc. 19, Esteban de Ibarra to Philip II, 11 January 1591, Lisbon.

Leg. 317 doc. 20, Esteban de Ibarra to Philip II, 19 January, 1591, Lisbon.

Leg. 317 doc. 42, Duke of Medina Sidonia to Philip II, 9 January 1591, Sanlúcar de Barrameda.

Leg. 317 doc. 43, Duke of Medina Sidonia to Philip II, 15 January 1591, Sanlúcar de Barrameda.

Leg. 317 doc. 181, Hernando de la Riva Herrera to Philip II, 12 January 1591, Santander.

Leg. 317 doc. 182, Agustín de Ojeda to Philip II, 11 January 1591, Deusto.

Leg. 317 doc. 183, Agustín de Ojeda to Philip II, 25 January 1591, Deusto.

Leg. 317 doc. 185, Hernando de la Riva Herrera to Philip II, 21 January 1591, Santander.

Leg. 317 doc. 186, Hernando de la Riva Herrera to Philip II, 21 January 1591, Santander.

Leg. 318 doc. 88, Hernando de la Riva Herrera to Philip II, 11 February 1591, Santander.

Leg. 318 doc. 91, Hernando de la Riva Herrera to Philip II, 24 February 1591, Santander.

Leg. 318 doc. 99, Luis de Fajardo to Philip II, 25 February 1591, Laredo.

Leg. 318 doc. 107, Pedro de Salinas to Philip II, 26 February 1591, Santander.

Leg. 318 doc. 109, *Licenciado* Gómez de la Puerta to Philip II, 26 February 1591, Bilbao.

Leg. 318 doc. 126, Duke of Medina Sidonia to Philip II, 20 February 1591, Sanlúcar de Barrameda.

Leg. 318 doc. 169, Agustín de Ojeda to Philip II, 15 February 1591, Deusto.

Leg. 318 doc. 170, Agustín de Ojeda to Philip II, 12 February 1591, Deusto.

Leg. 318 doc. 171, Agustín de Ojeda to Philip II, 28 February 1591, Deusto.

Leg. 318 doc. 172, Agustín de Ojeda to Philip II, 26 February 1591, Deusto.

Leg. 319 doc. 113, Agustín de Ojeda to Philip II, 12 March 1591, Deusto.

Leg. 319 doc. 114, Agustín de Ojeda to Philip II, 23 March 1591, Deusto.

Leg. 319 doc. 128, Martín de Bertendona to Philip II, 26 March 1591, Bilbao.

Leg. 319 doc. 133, Hernando de la Riva Herrera to Philip II, 2 March 1591, Santander.

Leg. 319 doc. 137, Riva Herrera to Philip II, 13 March 1591, Santander.

Leg. 319 doc. 142, Hernando de la Riva Herrera to Philip II, 25 March 1591, Santander.

Leg. 320 doc. 69, Hernando de la Riva Herrera to Philip II, 16 April 1591, Santander.

Leg. 320 doc. 104, Agustín de Ojeda to Philip II, 9 April 1591, Deusto.

Leg. 320 doc. 105, Agustín de Ojeda to Philip II, 12 April 1591, Deusto.

Leg. 320 doc. 106, Agustín de Ojeda to Philip II, 26 April 1591, Portugalete.

Leg. 320 doc. 107, Agustín de Ojeda to Philip II, 19 April 1591, Portugalete.

Leg. 320 doc. 108, Agustín de Ojeda to Philip II, 23 April 1591, Portugalete.

Leg. 320 doc. 122, Martín de Bertendona to Philip II, 19 April 1591, Portugalete.

Leg. 320 doc. 123, Martín de Bertendona to Philip II, 23 April 1591, Bilbao.

Leg. 321 doc. 123, Hernando de la Riva Herrera to Philip II, 5 May 1591.

Leg. 321 doc. 125, Hernando de la Riva Herrera to Philip II, 12 May 1591.

Leg. 321 doc. 126, Hernando de la Riva Herrera to Philip II, 12 May 1591.

Leg. 321 doc. 128, Hernando de la Riva Herrera to Philip II, 15 May 1591, Santander.

Leg. 321 doc. 130, Hernando de la Riva Herrera to Philip II, 19 May 1591, Santander.

Leg. 321 doc. 131, Hernando de la Riva Herrera to Philip II, 22 May 1591, Santander.

Leg. 321 doc. 145, Juan de Soto to Philip II, 12 May 1591, Santander.

Leg. 321 doc. 146, Juan de Soto to Philip II, 19 May 1591, Santander.

Leg. 321 doc. 148, Francisco de los Ríos to Philip II, 19 May 1591, Santander.

Leg. 321 doc. 150, Marcial de Arteaga to Philip II, 2 May 1591, Santander.

Leg. 321 doc. 173, Agustín de Ojeda to Philip II, 10 May 1591, Portugalete.

Leg. 321 doc. 174, Agustín de Ojeda to Philip II, 13 May 1591, Portugalete.

Leg. 321 doc. 179, Baltasar de Lezama to Philip II, 13 May 1591, Portugalete.

Leg. 321 doc. 194, Antonio de Urquiola to Philip II, 18 May 1591, Pasajes.

Leg. 322 doc. 34, Álvaro de Bazán to Alonso, 20 June 1591, El Ferrol.

Leg. 322 doc. 49, Diego Brochero to Philip II, 28 June 1591, El Ferrol.

Leg. 322 doc. 62, Antonio de Urquiola to Philip II, 28 June 1591, El Ferrol.

Leg. 322 doc. 77, Hernando de la Riva Herrera to Philip II, 2 June 1591, Santander.

Leg. 322 doc. 79, Hernando de la Riva Herrera to Philip II, 26 June 1591, Santander.

Leg. 322 doc. 98, Vasco Rodríguez to Philip II, 1 June 1591, Santander.

Leg. 322 doc. 99, Vasco Rodríguez to Philip II, 19 June 1591, Santander.

Leg. 322 doc. 100, Vasco Rodríguez to Philip II, 27 June 1591, Santander.

Leg. 322 doc. 105, Antonio de Urquiola to Felipe II, 2 June 1591, El Sardinero.

Leg. 322 doc. 108, Martín de Bertendona to Philip II, 9 June 1591, Portugalete.

Leg. 322 doc. 109, Martín de Bertendona to Philip II, 22 June 1591, Portugalete.

Leg. 322 doc. 110, Baltasar de Lezama to Philip II, 6 June 1591, Bilbao.

Leg. 322 doc. 112, Baltasar de Lezama to Philip II, 22 June 1591, Portugalete.

Leg. 322 doc. 114, Agustín de Ojeda, 9 June 1591, Portugalete.

Leg. 322 doc. 115, Galleons and other ships of Martín de Bertendona, 9 June 1591.

Leg. 322 doc. 116, Galleons and other ships of Martín de Bertendona, 9 June 1591.

Leg. 322 doc. 117, Galleons and other ships of Martín de Bertendona, 9 June 1591.

Leg. 322 doc. 120, Agustín de Ojeda to Philip II, 22 June 1591, Portugalete.

Leg. 322 doc. 122, Francisco de Fuica to Philip II, 22 June 1591, Portugalete.

Leg. 323 doc. 1, Conde de Fuentes to Philip II, 6 July 1591, Lisbon.

Leg. 323 doc. 15, Esteban de Ibarra to Philip II, 6 July 1591, Lisbon.

Leg. 323 doc. 35, Álvaro de Bazán to Philip II, 27 July 1591, El Ferrol.

Leg. 323 doc. 37, Bernabé de Pedroso to Philip II, 7 July 1591, El Ferrol.

Leg. 323 doc. 39, Juan Maldonado to Philip II, 7 July 1591, El Ferrol.

Leg. 323 doc. 45, Antonio de Urquiola to Philip II, 15 July 1591, El Ferrol.

Leg. 323 doc. 46, Antonio de Urquiola to Philip II, 23 July 1591, El Ferrol.

Leg. 323 doc. 79, Hernando de la Riva Herrera to Philip II, 4 July 1591, Santander.

Leg. 323 doc. 88, Agustín de Ojeda to Philip II, 5 July 1591, Portugalete.

Leg. 323 doc. 89, Agustín de Ojeda to Philip II, 9 July 1591, Portugalete.

Leg. 323 doc. 90, Agustín de Ojeda to Philip II, 12 July 1591, Portugalete.

Leg. 323 doc. 263, Juan Maldonado, 26 June 1591, El Ferrol.

Leg. 324 doc. 84, Fernando Gallinato to Philip II, 15 August 1591, El Ferrol.

Leg. 324 doc. 105, Agustín de Ojeda to Philip II, 20 August 1591, Deusto.

Leg. 326 doc. 126, Agustín de Ojeda to Philip II, 18 October 1591, Deusto.

Leg. 327 doc. 13, Álvaro de Bazán to Philip II, 1 November 1591, Lisbon.

Leg. 327 doc. 38, Antonio de Urquiola to Philip II, 2 November 1591, Lisbon.

Leg. 327 doc. 61, Hernando de la Riva Herrera to Philip II, 3 November 1591, Santander.

Leg. 327 doc. 76, Corregidor de Vizcaya to Philip II, 3 November 1591, Bilbao.

Leg. 327 doc. 78, Agustín de Ojeda to Philip II, 3 November 1591, Deusto.

Leg. 327 doc. 181, Agustín de Ojeda to Philip II, 18 October 1591, Deusto.

Leg. 328 doc. 94, Antonio de Urquiola to Philip II, 26 December 1591, El Ferrol.

Leg. 328 doc. 110, Antonio de Urquiola to Philip II, 7 December 1591, El Ferrol.

Leg. 328 doc. 125, Agustín de Ojeda to Philip II, 3 December 1591, Deusto.

Leg. 329 doc. 125, Philip II to Agustín de Ojeda, 17 January 1591, Madrid.

Leg. 330 doc. 151, Agustín de Ojeda to Philip II, 13 February 1591, Madrid.

Leg. 341 doc. 32, *Relacion de los mastiles que ay en Lisboa*, 11 January 1591, Lisbon.

Leg. 341 doc. 188, López de Soto, 12 August 1591, El Ferrol.

Leg. 341 doc. 204, Bernabé de Pedroso, 27 July 1591, El Ferrol.

Leg. 341 doc. 205, Bernabé de Pedroso, 27 July 1591, El Ferrol.

Leg. 341 doc. 206, Bernabé de Pedroso, 7 August 1591, El Ferrol.

Leg. 341 doc. 208, Álvaro de Bazán, 26 July 1591, El Ferrol.

Leg. 341 doc. 211, *Relacion de los galeones, naves, felipotes, pataches y zabras que de la armada de guarda han aportado a Lisboa*, 11 August 1591, Lisbon.

Leg. 347 doc. 140, Agustín de Ojeda to Philip II, 13 October 1589, Deusto.

Leg. 347 doc. 142, Agustín de Ojeda to Philip II, 27 October 1589, Deusto.

Leg. 347 doc. 145, Agustín de Ojeda to Philip II, 23 October 1589, Deusto.

Leg. 347 doc. 213, Philip II to Hernando de la Riva Herrera, 5 February 1589, Madrid.

Leg. 349 doc. 59, Bernabé de Alvia to Philip II, 19 February 1592, Pasajes.

Leg. 349 doc. 82, Juan de la Concha to Philip II, 15 February 1592, El Ferrol..

Leg. 349 doc. 87, Hernando de la Riva Herrera to Philip II, 14 February 1592, Santander.

Leg. 351 doc. 63, Antonio de Urquiola to Philip II, 15 April 1592, Santander.

Leg. 351 doc. 111, Antonio de Urquiola to Philip II, 28 April 1592, Pasajes.

Leg. 352 doc. 7, Antonio de Urquiola to Philip II, 1 May 1592, Pasajes.

Leg. 355 doc. 187, Antonio de Urquiola to Philip II, 27 August 1592, Pasajes.

Leg. 356 doc. 19, Antonio de Urquiola to Philip II, 4 September 1592, Pasajes.

Leg. 358 doc. 188, *Arqueamiento que se hizo en Portugalete de lo tres galeones nombrados* San Matías*,* San Bartolomé*, and* San Tadeo *de su Magestad*, 22 November 1592, Portugalete.

Leg. 372 doc. 184, Pedro de Ivella to Philip II, 9 April 1593, Naples.

Leg. 373 doc. 37, Pedro de Ivella to Philip II, 7 May 1593, Naples.

Leg. 379 doc. 243, Pedro de Ivella to Philip II, 20 November 1593, Naples.

Leg. 380 doc. 107, *Relacion de la frabrica de los doce galeones de Guerra de la esquadra Illyrica de Pedro de Yvella y Estefano Dolisti*, 17 December 1593.

Leg. 468 doc. 61, *Relacion de los navíos de Armada de su Magestad y de Particulares tanto galeones como otros navíos, hurcas y pataches que quedan en salbo en el Puerto del Ferrol de la Coruña y el cavo de Finisterra assi de los que salieron de Lisboa como de las diez y nueve urcas de Sevilla y de las toneladas que cada una tiene*, 6 November 1596, El Ferrol.

Leg. 481 doc. 3, *Relacion de los navíos y gente de mar y Guerra que se perdieron a 28 de Octubre sobre el cabo*, 1 January 1597.

Leg. 490 doc. 431, *Relacion de los navíos que ban en el Armada de Su Magestad y las toneladas que tienen y lo sbastimentos que cada uno lleva*, Bernabé de Pedroso, 4 October 1597, La Coruña.

Leg. 513 doc. 204, *Relacion de las medidas que tubieron los doze galeones levantiscos de la Esquadra del general Pedro de Ivella*, 12 March 1598, La Coruña.

AGS MPD 16, 164, *Dibujo de una nave agaleazada por Gregorio Sarmiento de Valladares*, 16 January 1589.

16, 165, *Porfilo de la anchira y altura que a de tener una galeaça en su medio que llaman la manga y la altura que ha de aver de cubierta a*

cubierta hasta la xareta, por Gregorio Sarmiento de Valladares, 16 January 1589.

16,179, *Este es el modelo de las asabras que al presente se an fabricado a orden de don Ernando Urtado de Mendoça en esta villa de Fuenterrabia en este año 1591*.

Secondary Sources

Alves, F., Rieth, E., and P. Rodrigues. 2001a. "The remains of a 14th-century shipwreck at Corpo Santo and of a shipyard at Praça do Municipio, Lisbon, Portugal." In *Trabalhos de Arqueologia 18. Proceedings. International Symposium on Archaeology of Medieval and Modern Ships of Iberian-Atlantic Tradition: hull remains, manuscripts and ethnographic sources: a comparative approach. Lisbon. September 7th to 9th, 1998*, edited by F. Alves, 405-26. Centro Nacional de Arqueologia Náutica e Subaquática (CNANS): Academia de Marina.

Alves, F., Rieth, E., Rodrigues, P., Aleluia, M., Rodrigo, R., Garcia, C., and E. Riccardi. 2001b. "Ria de Aveiro A: a shipwreck from Portugal dating to the mid-15th century; a preliminary report." *International Journal of Nautical Archaeology* (*IJNA*) 30.1:12-36.

Anes, G., Aldea, Q, Olmedo, J., Alonso, M., and I. Gómez. 2009-2013. *Diccionario biográfico español*. 50 vols. Madrid: Real Academia de la Historia.

Apestegui, C. 2001. "Arquitectura y construcción navales en la España Atlántica, el siglo XVII y primera mitad del XVIII. Una nueva sistematización." In *Trabalhos* *de Arqueologia 18. Proceedings. International Symposium on Archaeology of Medieval and Modern Ships of Iberian-Atlantic Tradition: hull remains, manuscripts and ethnographic sources: a comparative approach. Lisbon. September 7th to 9th, 1998*, edited by F. Alves, 163-212. CNANS: Academia de Marina.

Artíñano y de Galdácano, G. 1920. *La arquitectura naval española (en madera) bosquejo de sus condiciones y rasgos de su evolución*, Editada en Madrid: Por el autor.

Barker, R. 1986. "Fragments from the Pepysian Library." *Revista da Universidade de Coimbra* 32:161-78.

Barkham, M. 2007. "Report on 16th-Century Spanish Basque Shipbuilding, ca, 1550 to ca 1600." In *The underwater archaeology of Red Bay: Basque shipbuilding and whaling in the 16th century*, edited by R. Grenier, W. Stevens and M. Bernier, Vol. 5, 13-24. Ottawa: Parks Canada.

Bernier, M-A., and R. Grenier. 2007. "Dating and Identification of the Red Bay Wrecks." In *The underwater archaeology of Red Bay: Basque shipbuilding and whaling in the 16th century*, edited by R. Grenier, W. Stevens and M. Bernier, Vol. 4, 291-308. Ottawa: Parks Canada.

Boix, I. 1841. *Recopilación de leyes de los reinos de las Indias*. Vol. 4. Madrid: Boix, editor, impresor y librero, calle de Carretas, número 8.

Bojakowski, P. 2011. “The Western Ledge Reef Wreck: continuing research on the late 16th-/early 17th-century Iberian shipwreck from Bermuda.” *Post-Medieval Archaeology* 45/1:18-40.

___________. 2012. “Western Ledge Reef Wreck: The Analysis and Reconstruction of the Late 16th-Century Ship of the Spanish Empire.” Ph.D. diss., Texas A&M University.

Cano, T., and E.M. Dorta. 1964. *Arte para fabricar y aparejar naos, 1611*. La Laguna: Instituto de Estudios Canarios.

Casaban, J.L. 2017. “Santiago de Galicia and the Illyrian squadron: Characteristics, dimensions and tonnages of Mediterranean-built galleons for Philip’s II Atlantic fleets (1593-1597).” *The International Journal of Maritime History* (*IJMH*) 29(2):238-60.

Casado Soto, J. L. 2006. “Barcos para la guerra. Soporte de la Monarquía Hispánica.” *Cuadernos de Historia Moderna. Anejos.* 5:15-53.

___________. 2003. “La invencion del galeón oceánico de guerra español.” In *Naves, puertos e itinerarios marítimos en la época moderna,* edited by L. A. Ribot García and L. De Rosa, 37-70. España: Editorial Actas.

___________. 1998. "Aproximación a la tipología naval cantábrica en la primera mitad del siglo XVI", *Itsas Memoria.Revista de Estudios Marftimos del País Vasco,* 2:169-91.

___________. 1991b. “Atlantic Shipping in Sixteenth-Century Spain and the 1588 Armada”, In *England, Spain and the Gran Armada 1585–1604: Essays from*

Anglo-Spanish Conferences, London and Madrid, 1988 (Edinburgh, 1991), edited by María J. Rodríguez-Salgado and Simon Adam, 95–133. Edinburgh: John Donald.

___________. 1991a. "Los barcos del Atlántico Ibérico en el siglo de los Descubrimientos. Aproximación a la definición de su perfil tipológico." In *Andalucía América y el mar: Actas de las IX Jornadas de Andalucía y América*, edited by B. Torres Ramírez. Sevilla: Diputación de Huelva.

___________. 1988. *Los barcos españoles del siglo XVI y la Gran Armada de 1588*. Madrid: Editorial San Martín.

__________. 1976-1977. "Pescadores y linajes: estratificación social y conflictos en la Villa de Santander (Siglos XV y XVI)." *Altamira: Revista del Centro de Estudios Montañeses* 40:185-229.

Castro, F. 2011. "The Cais do Sodré Shipwreck, Lisbon, Portugal." *IJNA* 40.2:328-43.

_______. 2008. "In Search of Unique Iberian Ship Design Concepts." *Historical Archaeology* 42(2):63-87.

_______. 2003. "The Pepper Wreck, an early 17th-century Portuguese Indiaman at the mouth of the Tagus River, Portugal." *IJNA* 32.1:6-23.

Covarrubias, S.d., Arellano, I., and Zafra, R. 2006. *Tesoro de la lengua castellana o española*. Pamplona: Univeridad de Navarra.

Crescentio, B.1607. *Nautica mediterranea*. Roma: Appresso Bartolomeo Bonfadino.

Doran E. and M.F. Doran. 1978. “A Recnstruction of the Padra Island Ship.” In *The Nautical archeology of Padre Island: the spanish shipwrecks of 1554*, by J.B. Arnold, J. B. and R. Weddle, 375-89. New York: Academic Press.

Eberenz, R. 1975. Schiffe an den Küsten der Pyreäenhalbinsel: eine kultugeschichtliche Untersuchung zur Schiffstypologie und –terminologie in den iberoromanischen Sprachen bis 1600. Bern: Herbet Lang.

Emmer, P. C., and Gaastra, F.S., eds. 1996. *The Organization of Interoceanic Trade in European Expansion 1450-1800*. Aldershot: Variorum.

Escalante De Mendoza, J. 1985. *Itinerario de navegación de los mares y tierras occidentales 1575*. Madrid: Museo Naval.

Fernandes, M. 1989, *Livro de tracas de carpintaria*, Lisboa: Academia de Marina.

Fernandes, M., Leitão, M., and E. Barros. 1995. *Livro de tracas de carpintaria*. Lisboa: Academia de Marinha.

Fernández Duro, C. 1895-1903. *Armada española desde la unió de los reinos de Castilla y de León*. 9 vols. Madrid: Sucesores de Rivadeneyra.

__________Fernández Duro, C. 1876-1881. *Disquisiciones náuticas*. 6 vols. Madrid: Imprenta de Aribau y c.a. (sucesores de Rivadeneyra).

Fernández González, F. 2012. “The Spanish Regulations for Shipbuilding (Ordenanzas) of the Seventeenth Century,” *New Interpretations in Naval History: Selected Papers from The Sixteenth Naval History Symposium Held at the United States Naval Academy, 10-11 September 2009,* edited by Craig C. Felker and Marcus O. Jones. Newport, RI: Naval War College Press.

Fonseca, L. 2006. “A Escuadra Ilírica no Mar Oceano (1595-1598).” Ph.D. diss., University of Lisbon.

Fraga, T. M, and J.A. Bettencourt. 2017. “The Angra D wreck (Azores, Portugal). *Study and reconstruction of an Iberian ship.” In Ships and Martime Landscapes. Proceedings of the Thirteenth International Symposium on Boat and Ship Archaeology, Amsterdam 2012*, edited by J. Gawronsky, A. van Holk, and J. Schokkenbroek, 445-49. Eelde: Barkhuis Publishing.

Friel, I. 1984. “Notes on the Indentifcation and Reconstruction of the Wreck.” In *The Cattewater Wreck: the Investigation of an Armed Vessel of the Early Sixteenth Century*, by M. Redknapp, 135-39. Oxford: British Archaeological Report.

Garcia, C., and Monteiro, P. 2001. “The excavation and dismantling of Angra D, a probable Iberian seagoing ship, Angra bay, Terceira Island, Azores, Portugal. Preliminary assessment.” In *Trabalhos de Arqueologia 18. Proceedings. International Symposium on Archaeology of Medieval and Modern Ships of Iberian-Atlantic Tradition: hull remains, manuscripts and ethnographic sources: a comparative approach. Lisbon. September 7th to 9th, 1998*, edited by F. Alves, 431-47. CNANS: Academia de Marina.

Gaztañeta Yturribalzaga, A. 1720. *Proporciones de las medidas mas essempciales*. Madrid: Phelipe Alonso.

Gaztañeta Yturribalzaga, A., Fernández González, F., Apestegui Cardenal, C. and Miguélez García, F. 1992. *Arte de fabricar reales: edición comentada del* *manuscrito original de Don Antonio de Gaztañeta Yturribalzaga*. Barcelona: Lunwerg Editores.

González, J.A., Pablo, J.L., and Rodrigo, R. 1999. *Catálogo de la colección de documentos de Sanz de Barutell que posee el Museo Naval: serie Simancas*. Madrid: Ministerio de la Defensa, Museo Naval.

Goodman, D.C. 1997. *Spanish Naval Power, 1589-1665: Reconstruction and Defeat*. New York: Cambridge University Press.

Guilmartin, J.F. 2003, *Gunpowder and Galleys: Changing Technology and Mediterranean Warfare at Sea in the Sixteenth Century*. Annapolis: Naval Institute Press.

Hormaechea, C., Rivera, I., and Derqui, M. 2012. *Los galeones españoles del siglo XVII*. 2 vols. Barcelona: Associació d'Amics del Museu Marítim de Barcelona.

Imaz, J.M. 1944. *La Industria pesquera en Guipúzcoa al final del siglo XVI*. San Sebastián: Imprenta de la Diputación de Guipúzcoa.

Lane, F.C. 1992. *Venetian Ships and Shipbuilders of the Renaissance*. Baltimore: Johns Hopkins University Press.

________. 1934. "Venetian Naval Architecture." *The Mariner's Mirror* 20.1:34-49.

Lavanha, J. B. and Barker, R. 1996, *Livro primeiro da architectura naval. The first book of naval architecture*. Lisboa: Academia de Marinha.

L'Hour. 1996. "Naval construction." In *Treasures of the San Diego*, by J-P. Desroches, G. Casal, Goddio, F., and A. Giordan, 118-53. Paris: AFAA.

Loewen, B. 2007. “Archaeology of a 16th-Century Basque Whaling Ship: Concepts and Questions.” In *The underwater archaeology of Red Bay: Basque shipbuilding and whaling in the 16th century*, edited by R. Grenier, W. Stevens and M. Bernier, Vol. 3, 13-24. Ottawa: Parks Canada.

Lovegrove, H. 1964. “Remains of Two Old Vessel Found at Rye, Sussex.” *The Mariner’s Mirror* 2:5-22.

Malcom, C. 1996. "St. John's Bahamas Shipwreck Project, Interim Report 1: The Excavation and Artifacts, 1991-1995.” Mel Fisher Maritime Heritage Society, Inc. Key West, Florida.

Meehan, P., and F. Trejo. 2008. “Nuestra Señora del Juncal: her story and her shipwreck.” In *Underwater and maritime archaeology in Latin America and the Caribbean*, edited by M. E. Leshikar-Denton and P. Luna Erreguerena, Walnut Creek: Left Coast Press.

Menéndez de Avilés, P, Ruidiaz y Caravia, E., Barcí Carballido y Zúñuga, A., and G. Solís de Merás. 1893. *La Florida: su conquista y colonización*. 2 vol. Madrid: Imp. De los hijos de J.A. García.

Monson, W. 1902. *The Naval Tracts of Sir William Monson.* Vol. 3. Edited with a commentary drawn from the state papers and original sources by M. Oppenheim. London: Navy Records Society.

Moya. C. 1981. “La arquitectura naval de los Austrias.” In *El Buque en la Armada española*, edited by E. Manera, 147-67. Madrid: Silex.

Navarrete, M.F. de. 1971. *Colección de documentos y manuscritos compilados*. 32 vols. Nendeln: Liechtenstein.

_____________. 1851. *Biblioteca marítima española, obra póstuma*. 2 vols. Madrid: Imprenta de la viuda de Calero.

_____________. 1825-1837. *Colección de los viajes y descubrimientos que hicieron por mar los españoles desde fines del siglo XV: con varios documentos inéditos concernientes a la historia de la marina castellana y de los establecimientos españoles en Indias*. 5 vols. Madrid: Imprenta Real.

Oertling, T. J. 2004 "Characteristics of fifteenth- and sixteenth-century Iberian ships." In *The philosophy of shipbuilding : conceptual approaches to the study of wooden ships*, edited by F. M. Hocker and C. A. Ward, 129-36. College Station: Texas A&M University Press.

______________. 1989b. "The Highborn Cay wreck: The 1986 field season." *IJNA* 18.3:244-53.

______________. 1989a. "The Molasses Reef wreck hull analysis: Final report." *IJNA* 18.3:229-43.

Oliveira, F. 1991, *Livro da fabrica das naos*. Lisboa: Academia de Marinha.

O'Scanlan, T. 1831. *Diccionario marítimo español : que ademas de la definiciones de las voces con sus equivalentes en frances, ingles e italiano, contiene tres vocabularios de estos idiomas con las correspondencias castellanas : redactado por orden del Rey nuestro señor*. Madrid: en la imprenta real.

Palacio, D.G. de. 1944. *Instrucción náutica para navegar. Obra impresa en México*. Madrid: Ediciones Cultura Hispánica.

Parry, J.H. 1990. *The Spanish Seaborne Empire*. Berkeley: University of California Press.

Phillips, C. R. 2007. *The treasure of the San José death at sea in the War of the Spanish Succession*. Baltimore: Johns Hopkins University Press.

___________. 1994, 'The Galleon.' In *Cogs, Caravels and Galleons: The Sailing Ship 1000–1650,* edited by R. Gardiner and R.W. Unger, 98–114. Annapolis: Naval University Press.

___________. 1992. *Six Galleons for the King of Spain: Imperial Defense in the Early Seventeenth Century*. Baltimore: Johns Hopkins University Press.

___________. 1990. *Los Tres Reyes, 1628-1634: the Short Life of an Unlucky Spanish Galleon*, 2nd ed. Minneapolis: University of Minnesota Press.

Redknap, M. 1984. *The Cattewater wreck: the investigation of an armed vessel of the early sixteenth century*. Oxford: B.A.R.

Real Academia Española. 2014. *Diccionario de la lengua española*. Madrid: Real Academia Española.

Rieth, E. 1988. "Essai de restitution d'un batiment de 400 toneladas, d'apres Diego Garcia de Palacio (1587)." *Histoire & Mesure* 3.4:463-89.

Rodriguez, B. 2008. "The Spanish Navy and the Ordenanzas of 1607, 1613, and 1618." In *The Edge of Empire. Proceedings of the Symposium held at SHA 2006,* *Sacramento, California*, edited by F. Castro and K. Custer, 79-151. Casal de Cambra: Caleidoscopio.

Rosloff, J., and Arnold, J.B. 1984. “The keel of the *San Esteban* (1554): continued analysis.” *IJNA* 13.4:287-96.

Rubio Serrano, J. L. 1991, *Arquitectura de las naos y galeones de las flotas de Indias*. 2 vols. Málaga: Seyer.

Sañez Reguart, A. 1791-1795. *Diccionario histórico de las artes de la pesca nacional*. 5 vols. Madrid: en la imprenta de la Viudad de Don Joaquín Ibarra.

Serrano Mangas, F. 2012. *Los tres credos de Don Andrés de Aristizábal: ensayo sobre los enigmas de los naufragios de la Capitana y la Almiranta de la Flota de Nueva España de 1631*. México: Universidad Veracruzana.

__________. 1992. *Función y evolución del galeón en la carrera de Indias*, Madrid: Editorial MAPFRE.

__________. 1989. *Armadas y flotas de a plata (1620-1648)*. Madrid: Banco de España.

__________. 1985. *Los galeones de la Carrera de Indias, 1650-1700*. Sevilla Escuela de Estudios Hispano-Americanos de Sevilla, CSIC.

Smith, R. C. 1993. *Vanguard of Empire: Ships of Exploration in the Age of Columbus*. New York: Oxford University Press.

Smith, R.C., Spirek, J., Bratten, J., and D. Scott-Iretton. 1995. *The Emanuel Point Ship: Archaeological Investigations, 1992-1995, Preliminary Report*. Tallahassee Bureau of Archaeological Research.

Steffy, J.R. 1994. *Wooden Ship Building and the Interpretation of Shipwrecks*. College Station: Texas A&M University Press.

Stradling, R.A. 2006. "Antonio de Oquendo, Basque Seafaring Traditions and National Mythologies: A Historical-Ethical Essay." *Itsas Memoria. Revista de Estudios Marítimos del País Vasco* 5:145-55.

Thomsen, M.H. 2000. "The Studland Bay wreck, Dorset, UK: hull analysis." *IJNA* 29.1:69-85.

Trejo, F. 2003. *La flota de la Nueva España, 1630-1631: vicisitudes y naufragios*. México, D.F.: Instituto Nacional de Antropología e Historia.

Vargas, J. and San Pío, P. 1979. *Catálogo de la colección de documentos de Vargas Ponce que posee el Museo Naval: (serie primera: numeración romana)*. Madrid: Instituto Histórico de Marina.

Vicente Maroto, M.I. 2006. "Agustín de Ojeda y la construcción de navíos a finales del siglo XVI." In *La ciencia y el mar*, edited by M.I. Vicente Maroto y M. Esteban Piñeiro, 311-44. Valladolid: Sever-Cuesta.

_____________. 1998. *Diálogo entre un vizcayno y un montañes sobre la fábrica de navíos*. Salamanca: Ediciones de la Universidad de Salamanca.

Visiers, R. 2015. "La aportación de la Península Ibérica a la tecnología naval avanzada a través de los documentos y la reproducción de los buques descritos en ellos (1570-1620). Ph.D. diss., Escuela Técnica Superior de Ingenieros Navales.