STANDARDIZATION OF SPANISH SHIPBUILDING: ORDENANZAS PARA LA FÁBRICA DE NAVÍOS DE GUERRA Y MERCANTE – 1607, 1613, 1618

A Thesis

by

BLANCA MARGARITA RODRÍGUEZ MENDOZA

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

MASTER OF ARTS

December 2008

Major Subject: Anthropology

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Approved by:

Chair of Committee,	Filipe Vieira de Castro
Committee Members,	Kevin Crisman
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ABSTRACT

Standardization of Spanish Shipbuilding: Ordenanzas para la fábrica de navíos de guerra y mercantes - 1607, 1613, 1618. (December 2008)

Blanca Margarita Rodríguez Mendoza, B.A., Texas A&M University

Chair of Advisory Committee: Dr. Filipe Vieira de Castro

During the first two decades of the 17^{th} century King Philip III (1598-1621) of Spain and Portugal launched an effort to standardize all shipbuilding in the Iberian Peninsula. These efforts of standardization constitute an important collection of information about Iberian shipbuilding practices of that period. This thesis will analyze the content of the three sets of ordinances, issued in 1607, 1613 and 1618, in the context of the history of the Iberian Peninsula, the regulation of the *Carrera de Indias* (Indies Trade), and Spanish shipbuilding practices based on written sources of that period.

DEDICATION

To Wayne and Helen

(and Petrus and Kuro)

ACKNOWLEDGMENTS

I would like to thank my committee chair, Dr. Castro, for his guidance and advice, and my committee members Dr. Crisman and Dr. Kallendorf for their useful suggestions on how to improve this work.

I am very grateful to Dr. Dewolf and Dr. Smith for their support, because they were always there when I needed advice (or anything else!).

Thanks to Donna and Bill Wilder for their never ending support and for the marvelous Wilder 3-D lab, where I spent countless hours learning amazing things.

I would also like to thank Dr. Ma. Isabel Vicente Maroto and her family, and the personnel at the Archivo General de Simancas and the Museo Naval de Madrid for making my research in Spain such a pleasant experience.

Thanks to my parents for their unconditional support, to my sister for her encouragement, and to my brother Alvaro, who acted as my thesis representative.

Special thanks to my friends Carlos, Elvis, and Itza for giving me a hand while in College Station.

NOMENCLATURE

AGI: Archivo General de Indias

AGS: Archivo General de Simancas

BNM: Biblioteca Nacional Madrid

MNM: Museo Naval de Madrid

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CHAPTER I

INTRODUCTION

From its beginning and throughout the 16th century, the *Carrera de Indias* or Indies Trade was carefully regulated as part of the Spanish crown's strategy to create perhaps one of the first true world empires. By regulating the most important aspects of the sea-lanes that connected the empire (i.e. the formation of a fleet system, the routes and their timing, as well as the establishment of *armadas* for the protection of the fleets), Spain became the most important European naval power during this period.

By the end of the 16th century, Spain's naval power was increasingly threatened by the rising importance on the naval field of a number of Protestant nations, mainly England and the Northern Netherlands. Assuming the role of Catholic defender, Spain invested a large portion of the monetary resources obtained from its colonies into a number of holy wars with these nations, causing a constant strain on the crown's finances, and thus putting its naval power at risk.

Following the 1588 Spanish Armada episode (in which King Philip II of Spain [1556-1598] failed an attempt to invade England) and the disastrous 1601 Ireland campaign of King Philip III of Spain (1598-1621), the latter monarch realized the necessity of maintaining Spanish hegemony at sea. After arranging peace treaties with his main enemies (France in 1598, England in 1604, and the Northern Netherlands in 1609), Philip III and his *Consejo de Guerra* focused their attention on a previously

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This thesis follows the style and format of *American Journal of Archaeology*.

overlooked aspect of the *Carrera de Indias*: the regulation of Spanish shipbuilding as a means to regain Spanish supremacy at sea.

The result was a series of three royal decrees known as the *ordenanzas para la fábrica de navíos de guerra y mercantes* (ordinances for the construction of war and merchant ships). These ordinances encompassed an effort to standardize all shipbuilding in the Iberian Peninsula. Triggered by the necessities of operating a modern state, and mandated by the demands of the crown's extensive empire, these efforts of standardization constitute an important collection of information about shipbuilding practices of that period. This thesis will analyze the content of the ordinances issued in 1607, 1613, and 1618, in the context of the history of the Iberian Peninsula during this period.

Because of the lack of archaeological material regarding the manner in which Spanish vessels for the trans-Atlantic trade and its protection were built during the late 16^{th} and early 17^{th} centuries, the study of the historical record of this period is particularly important. Luckily, in addition to the ordinances, a number of documents regarding the shipbuilding process of that period have survived. Included in these are four Spanish navigation and shipbuilding treatises and a handful of contracts and correspondence detailing the measurements of vessels' capacity.

Furthermore, there has not been a great deal written on the topic in secondary sources, since the study of the primary sources has been deemed more important. The texts that include information about the ordinances are mostly focused on the historical impact of the regulations in the larger concept of shipbuilding during the early 17th century. Of these, only one study of the contents of the 1613 and 1618 ordinances has been published by José Luis Rubio Serrano, although it is not complete. To my knowledge, no in-depth study has been done regarding the contents of the 1607 ordinances.

This study of the ordinances will be conducted by analyzing the primary sources available. The system of measurements used in ship design, as provided by the four Spanish treatises previously mentioned, will be reviewed in order to provide the context of the system of measurements used in Spain before the publication of the ordinances, during the transitional period of the publication of the ordinances, and after that period. The study of the trends of the particular measurements considered in the hull design and in the calculation of ship's tonnage will also include relevant information contained in correspondence and contracts.

The most important primary sources used in this study will be the ordinances themselves. The ordinances were usually divided into five topics (measurements, fortifications (hull structure), calculation of tonnage, rigging, and the payment for the shipbuilders and their tools). This study will focus primarily on the first three. A comparison of the contents of the three ordinances in what pertains to these subjects will provide valuable information on the different levels of standardization achieved with the regulations, as well as an accurate portrayal of the trends in the defining measurements, the types of ships, and the methods for calculating the tonnage. Correspondence from and to the *Consejo de Guerra*, the organization in charge of the publication of the ordinances, will be used to establish the historical background that led to the establishment of these regulations.

The aim of this study is to provide an overview of the ranges of the different ship proportions and the methods recommended for calculating the tonnage, as they were specified by the ordinances. Detailed sections will try to place the ordinances in the larger picture of the regulations issued by the Spanish government for the Indies Trade and of Spanish shipbuilding trends during the last quarter of the 16th and early 17th century.

Chapter II reviews the laws and regulations established by the Spanish crown during the 16th and early 17th centuries regarding the Indies trade. The discussion traces the origins of the fleet systems used by the Spaniards in their trans-Atlantic voyages. Then, it explores the trade routes used to connect the Spanish Iberian Peninsula with its colonies in the New World. Throughout the chapter, the system for protecting the trade is also examined. The chapter concludes with a discussion of the benefits provided by the close control of the Spanish crown.

Chapter III presents the types of vessels used for the *Carrera de Indias*, the defining measurements used in ship design and construction, the scope of the information pertaining to shipbuilding as it is presented by the Spanish navigation and shipbuilding treatises mentioned above, and other relevant archival material (i.e. correspondence, contracts) that include information on ship design and the calculation of tonnage.

Chapter IV focuses on the historical background of the ordinances and on the study of the defining design measurements and methods for calculating tonnage, as presented by each of the ordinances.

Chapter V provides a brief discussion that serves as the conclusion of the present study.

CHAPTER II

SPAIN AND THE CARRERA DE INDIAS

Spain was the first European nation to build and maintain a true world empire, where the king's will was imposed no matter how far away from Spain its subjects were. To properly rule this vast empire, it was essential for Spain to be able to maintain a strict control over the communication routes across several oceans. As historian J. L. Casado Soto points out, "technically (and logically) this [maintaining the empire] would have not been possible unless Spain possessed by this time the necessary organization, seamanship, armament, and quite specifically, shipping merchant fleet."[1] Throughout the 16th century Spain was the European nation with the highest volume of maritime trade. This was true even before Spain took over Portugal in 1580 under Philip II. Together, the two Iberian powers possesed about 300,000 tons of shipping, considerably more than the Dutch at 232,000, and out of sight of lesser shipping powers such as France and England.[2] This achievement was made possible by the careful regulation of the Indies trade system, which became known as the *Carrera de Indias*.

The Carrera de Indias in a Period of Maritime Reconnaissance

Christopher Columbus arrived at Puerto de Palos, Spain on March 15, 1493 completing his first round trip to the Americas. Included in the goods that the Admiral brought back from his first voyage into the *Mar Océano* was gold. Because of the precious metal, the Spanish monarchy was persuaded to send a second expedition.[3] This new venture, still under the command of Columbus, left Cádiz in September 1493. Columbus had orders to continue with the exploration of the lands he had discovered. This second voyage would mark the continuation of the Spanish ventures into the Atlantic and the beginning of an era of maritime reconnaissance, with only a few conquests taking place, which lasted from 1493 to 1519.[4]

The year 1493 also brought the first set of regulations passed by the monarchy regarding the Indies trade. In this year, Ferdinand and Isabella issued a letter forbidding private entrepreneurs from establishing trade with the Indies.[5] The regulation would be overruled in 1495, when rumors of Columbus' death persuaded the monarchy to open the trade with the Indies. By 1499, the voyages of discovery financed with private funds began, but under the restriction that all vessels should carry on board one government representative in charge of enforcing Royal rights.[6]

The first stage of the *Carrera de Indias* had begun and soon new controls were required on the part of the government. In 1503 Queen Isabella founded the *Casa de la Contratación,* or House of Trade, in Seville. The primary function of the organization was the regulation of the Indies trade. The *Casa* was in charge of appraising the vessels in order to control the character and size of the outbound cargoes that were to be shipped to the various ports of the *Islas*; and from the areas under Spanish control throughout the 16th century, to the ports of *Tierra Firme*. A distinction in the colonial territories was made through the use of the terms *Islas* and *Tierra Firme*. The term *Islas* was used when referring to the Caribbean Island colonies. The term *Tierra Firme* was used for the mainland colonies. When the vessels returned to Spain, it was the *Casa* that would receive all the goods and commodities imported from the Indies. This organization was also in charge of distributing the merchandise in the Spanish and European markets, always making sure that the Spanish crown received its fair share. In short, through the *Casa de la Contratación* the monarchy chose to remain in close control of the *Carrera de Indias*. The *Casa de la Contratación* also trained the pilots, made maps and charts, functioned as a post office and fulfilled important legal functions.[7]

After the establishment of the *Casa*, the Indies traffic observed a constant increase. In 1504, the first three private merchant *naos* registered by the *Casa* were dispatched.[8] From the years 1506 to 1508, the trade experienced an accelerated expansion. In 1506, twenty-three vessels with a combined carrying capacity of 2,160 tons left for the Indies.[9] Only two years later, in 1508, the number of vessels that left for the ports of the Greater Antilles had almost doubled. That year 45 vessels with a combined carrying capacity of 4,580 tons were dispatched.[10] This trend would reach its peak in 1520, when 71 vessels with a combined carrying capacity of 7,030 were dispatched.[11]

Throughout the first decade of the new century Spanish vessels crossed the Atlantic alone and without any extra protection. Corsairs were not yet a serious problem. The fact that the traffic to the Indies was still in its beginning stages, that the routes were new, and that this trade had not yet been widely recognized as a profitable business, kept foreign intruders away. The relative lack of pirates provided a reasonably safe voyage. Nevertheless, the Spanish monarchy took precautionary actions. In 1507, for example, two caravels were dispatched to protect the vessels on their return voyage, and in 1512 the King sent two armed vessels to the Canaries, in order to protect the ships from French corsairs aided by the Portuguese.[12]

The Carrera de Indias in a Period of Conquests

The first 25 years of the enterprise in the New World were characterized by constant maritime reconnaissance of the Caribbean basin and surrounding territory. Starting in 1519 this pattern changed and a second stage in the expansion of the Spanish Empire began. The new period, which lasted until the 1560's, was characterized by the exploration and settlement of the mainland, commonly referred to as *Tierra Firme*.

Once established in the Caribbean, the Spaniards undertook periodic voyages to the north and south, and from 1509 onwards, they made contact with the indigenous populations of the mainland.[13] Such contact was typically followed by conquest. Hernán Cortés started the reconnaissance of the Mexican coast in 1519, and just three years later, in 1521, Mexico had fallen into Spanish hands.

In the following 10 years the Spanish expansion continued towards Central and South America. During the third decade of the 16th century Spaniards based in the Isthmus of Panama began expeditions down the Pacific coast of South America.[14] Francisco Pizarro commanded one expedition that in January 1531 entered Incan territory. It did not take long before this empire, too, became part of the Spanish one. At the end of 1533 the first vessel carrying news and treasure from the newly conquered territory arrived in Seville.[15]

The trade to the Indies had risen increasingly from 1493 to 1520. During the following three years the trade dropped due to the combined factors of less production of gold in the Antilles and a new war with France.[16]

The recovery of the trade with the Indies began in 1524 and extended into the 1530's. With the first news of the mainland conquests and of new sources of treasure many Spaniards flocked to the New World to try to get their share of the loot. The new influx of settlers increased the demand for consumer goods from Europe. Simultaneously, with the addition of new territories, the amount of raw materials and goods obtainable from the Indies increased. At this time the most important export from the Indies was the gold obtained from Mexico. The silver trade was still in its early years. Other products obtained from the Indies trade during this period include sugar and hides from the Antilles, pearls from Venezuela, dyewoods from Campeche and Honduras, and cochineal from Mexico.[17]

The rise of trade between the two sides of the Atlantic Ocean attracted the first pirates and privateers. By the second decade of the 16th century there were signs that French pirates were becoming a problem in the eastern Atlantic, and their activities increased with the outbreak of war between France and Spain in 1521. As a result, in 1522, the merchants involved in the Indies trade pressed Charles I of Spain (1516 – 1556) to provide an *armada* that would protect their vessels from enemy attack.[18] The Spanish crown had no standing navy or the means to create one. As a result, the first contingent sent to protect the Atlantic routes had to be funded by a tax charged on the merchandise being exported and imported. The tax, known as the *avería*, provided funding for the protection of the fleets from this period onwards.

Although the first *armadas* were created during this period, corsair attacks did not fade. New actions had to be taken to control this problem. After 1524 vessels were no longer allowed to make the trans-Atlantic return voyage without military escort.[19] Two years later, in 1526, the crown prohibited isolated voyages for the entire length of the sea-routes. From this moment on, the crossing of the Atlantic was arranged into a system of fleets, or *Flotas*. Although sometimes these terms are presently used in an interchangeable manner, from the 16th century on, the term *Flota* was used when referring to merchant fleets and the term *Armada* when referring to military formations.

Historian J.A. Castillo Juárez points out that during this period "the interest of the crown in the protection of the commerce carried out by its subjects and of its own treasure is clear. It is also clear that the crown could not assume alone the financial burden of its defense."[20] King Charles I soon realized this and, in order to assure the protection of the fleets, ordered that merchant vessels be armed. In order to ensure that the vessels were properly manned and armed, in 1537 he issued the first ordinance that attempted to standardize the composition of the crews as well as the quantity of ammunition and artillery that should be carried on board any vessel participating in the *Carrera de Indias*.[21] In addition, the king ordered that heavily armed warships were to be sent with each convoy, and these once again were to be funded with the *avería*. And so it was that under King Charles I, the fleet system was founded.

Regulation of the Fleet System

The winds and currents of the Atlantic defined the routes of the *Carrera de Indias* from its early stage (Fig. 2-1). When the Antilles were the center of exploration and trade, vessels followed the prevailing winds from Seville south to the Canaries and westwards across the Atlantic into the ports of San Juan, Santo Domingo and Santiago de Cuba. With the conquest of Mexico, the New Spain routes extended to Veracruz. After the conquest of Peru the new route of *Tierra Firme* was added; it passed through the Lesser Antilles and thence to Nombre de Dios in Panama. After unloading their cargoes and filling their holds with goods from the Americas, the vessels entered the Gulf Stream, and returned home.[22] The system of two convoys, one bound to the New Spain viceroyalty and the other to Panama, would be followed throughout the duration of the *Carrera*.

To govern the newly acquired mainland territory the Spanish monarchy opted for a system of viceroyalties. In this system a viceroy, who answered directly to the Spanish monarch, controlled the civil, political and economic administration, acting just as the sovereign would have done if present. Because the means of communication were slow during the earlier stages of the viceroyalties, the powers of the early viceroys exceeded those of later ones. The process of informing the king of the events and waiting for a response often took several months. Therefore, the viceroy in most cases had to take the proper measures in all practical issues without awaiting the orders of the monarch.[23] The first viceroyalty created was that of New Spain (*Virreinato de la Nueva*

Figure 2- 1. Map of the winds and currents of the Atlantic and Pacific Oceans that helped delineate the Spanish trade routes. (After Cerezo Martínez 1988, 39)

España), established in 1535, and was followed by the creation of the Viceroyalty of Peru (*Virreinato del Perú*) in 1542 (Fig 2-2). The trade routes were directed to these two viceroyalties, with the viceroyalty of Peru being connected to the Atlantic through the Isthmus of Panama.

The navigation routes to the Indies, from the time of the founding of the *Casa de la Contratación* in 1503, officially started and ended in Seville (Fig 2-3). According to the historian Pérez-Mallaína, this city was chosen for several reasons. The first of them was the fact that the chosen port had to be strategically situated on the way towards the Canary Islands. Pérez-Mallaína considers Seville ideal because during this period it was Spain's most densely populated city, which allowed proper maintenance of the fleets. The second reason was that Seville was already an important administrative center, and would give the monopoly of the Indies' traffic to the region of Castile. The third and final reason was that Seville was located in one of the few agriculturally-prosperous areas of the Spanish Iberian Peninsula and was able to produce enough surplus food to feed the crews.[24]

Another characteristic of Seville that would prove advantageous to some extent, although it would become disadvantageous later, was its location in the interior of the Iberian Peninsula. Seville's distance of 100 kilometers away from the coast meant that the city was well protected from attack by enemy fleets. The drawback was that Seville was a fluvial port, and the Guadalquivir River had a limited capacity to receive vessels of great tonnage. During the 16th century, it was convenient because few vessels exceeded 200 tons in capacity, but during the 17th century the tonnage of ships

Figure 2- 2. Spanish viceroyalties.

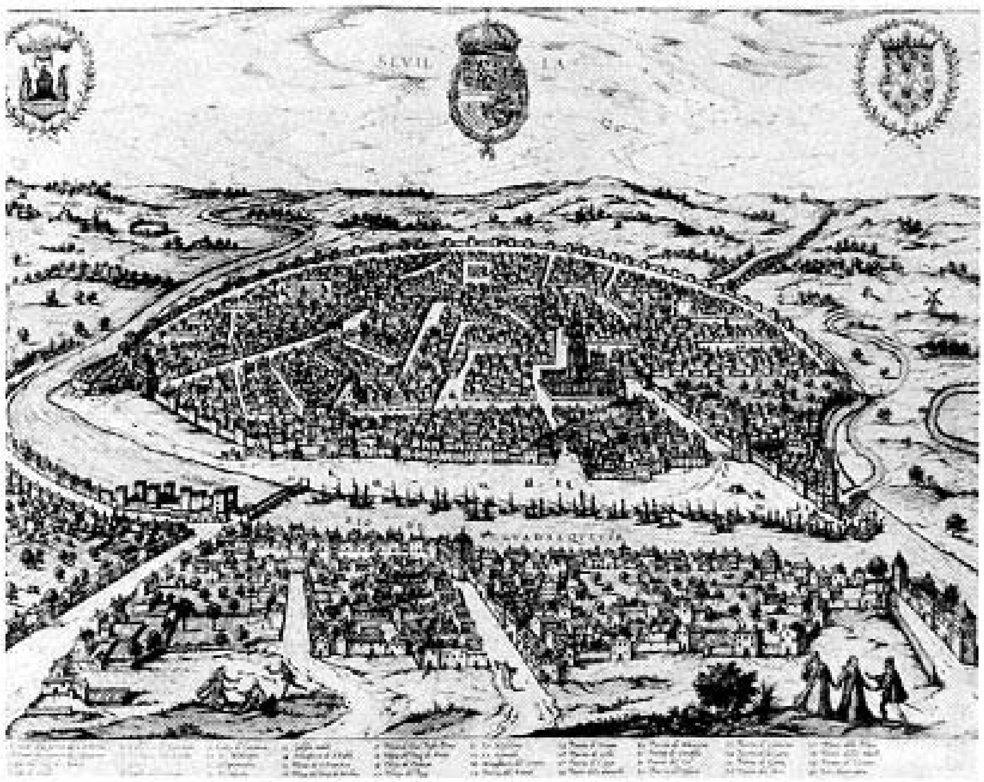

Figure 2- 3. Sixteenth-century Seville with the Indies Fleet preparing to sail.
(After Ward 1993, 90)

rapidly increased and in the end this situation would prove to be the downfall of Seville as the uniting port of the peninsula and the Indies. Throught the history of the *Carrera de Indias* the rivalry between the ports of Cádiz and Seville played an important role. In 1526 Seville was named the only port of origin for trading with the Indies. Many argued that the main inconvenience of Seville were the shallows of the Guadalquivir. Although more exposed to the possibility of enemy attacks, Cádiz was considered to have easier access to the sea. Occasionally, as in 1571, the fleet was authorized to arrive at Cádiz, although all treasure had to be taken to Seville. The conflict was finally resolved when the *Casa de la Contratación* moved to Cádiz in 1717.

The voyage towards the Indies was initiated with the navigation down the Guadalquivir River. The passage from Seville to the port of Sanlúcar de Barrameda would prove to be one of the slowest and most dangerous parts of the routes. The Guadalquivir was full of treacherous sand bars and in many places, when the tide was low, the water levels could be as low as 60 cm. The most dangerous areas in the Guadalquivir are described in Juan de Escalante de Mendoza's navigation treatise *Itinerario de Navegación*, written in 1575. The first location was the *Pilares*, which were the posts of an old bridge, against which many vessels were damaged. The second and third places were, according to his considerations, the most dangerous shallows. The former area was that known as the *Albayle*, situated two leagues away from Seville (1 Spanish league = 5.555 km). The latter, known as the *Naranjal*, was situated four leagues (22.22 km) away from Seville. When the winds and water levels of the river were favorable, the 89 kilometers that separated Seville from Sanlúcar could be traveled in one week. Pérez-Mallaína notes "at that speed, anyone walking would reach Sanlúcar sooner than the fastest of vessels of the fleets."[25] For this reason, only the small vessels would leave the Port of Muelas, in Seville, fully loaded. Vessels of medium and large tonnage left port practically empty. The vessels of medium tonnage were fully loaded in the Port of Horcadas, and those of large tonnage only half loaded. These last ones would not be completely loaded until they reached Sanlúcar and the sea.

Once the shallows of the Guadalquivir were left behind, the vessels started the voyage towards the Canary Islands. Both fleets sailed to a latitude of about twenty degrees, and past the Golfo de Yeguas on the Atlantic coast (Fig. 2-4). Seven to ten days after leaving the Guadalquivir the fleets would reach the Isla del Hierro in the Canaries Archipelago.[26]

Having traveled about two hundred leagues, or about 1,100 km, a stop at the Canaries provided the fleets with a chance to replenish their provisions (Fig. 2-4), especially fresh water and firewood. At this stop the fleets also repaired any damages that had occurred to the vessels as a result of the first stages of the journey. Gran Canaria, Gomera, and Palma in the Canaries Archipelago were considered the best islands at which to stop.

The stop at the Canaries also opened the possibility of engaging in illicit trade. Merchants unloaded some of their cargo and traded with local people. Then, under the excuse of replenishing their victuals, they took in new unregistered merchandise to be sold in the Indies. Another type of illicit traffic involved vessels, many of them

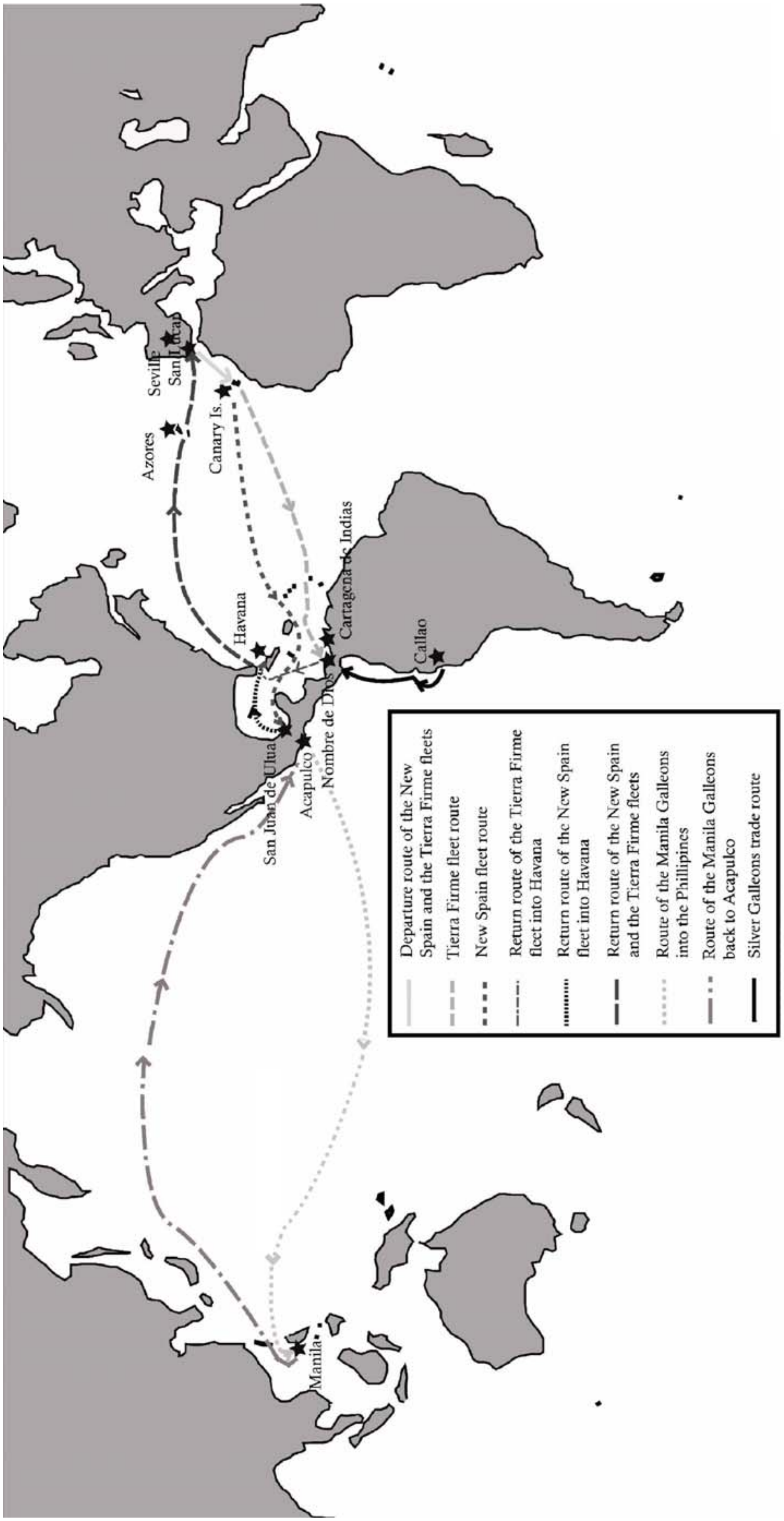

Figure 2- 4. Spanish trade routes.

Portuguese, which left the Canaries without licenses, or planned to arrive at unofficial ports.[27]

When talking about illicit trade in the New World, Castillo Juárez remarks, "illicit traffic was a phenomenon that not only damaged the monopolist interests of the Spanish merchants. The continuity of the system as a whole was implicated."[28] The reason for this was that many merchants, choosing to participate in illicit trade, stopped paying the rights and taxes incurred with legal trade. But what is most important, by evading the *avería,* they put the system of protection at risk. The Spanish monarchy took very seriously the regulation regarding illicit traffic. One measurement taken was to forbid a stop at the Canaries. By 1593, the fleets of New Spain avoided passing through these islands.

From the Canary Islands, the convoys sailed into the Atlantic (Fig. 2-4). Their next landfall was typically the islands of La Deseada, La Dominica, Todos Santos, Marigalante, Guadalupe or any other island in the vicinity of the Lesser Antilles. From the Canaries the voyage to the Lesser Antilles lasted about a month and approximately 800 leagues or about 4,400 km were traveled. Most of the time, stopping at the Lesser Antilles was avoided, unless there was an urgent need to replenish supplies.[29] From this point on the routes going to New Spain and *Tierra Firme* would divide (Fig. 2-5).

The fleet bound for New Spain continued its way towards Puerto Rico. After a stop at the port of San Juan, the ships traveled along the southern coast of the Hispaniola. From the island of La Deseada to Santo Domingo, the official port of Hispaniola, the fleets had to travel about 150 leagues, or about 825 km. The route of the

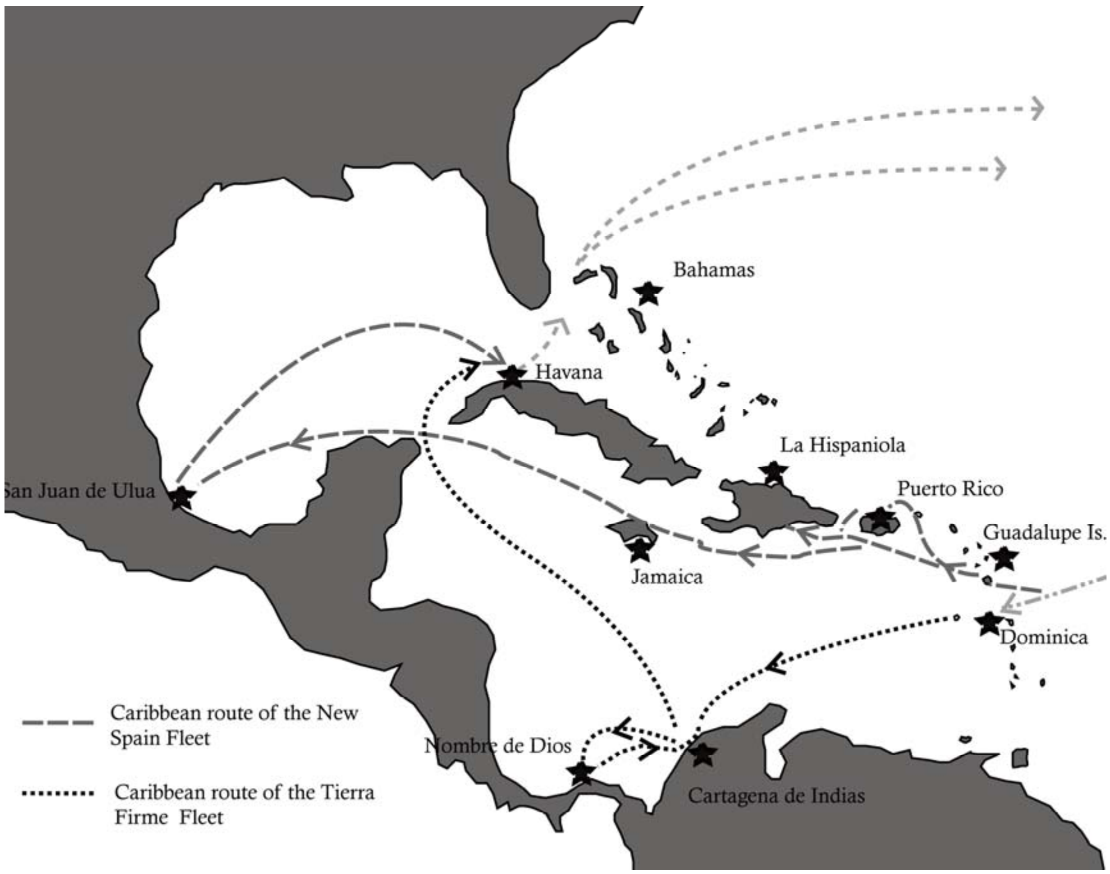

Figure 2- 5. Detail of the Caribbean routes.

New Spain fleet continued towards the port of Ocoa and from there to the cape of San Antón, navigating past the north coast of Jamaica. The vessels that were bound for Honduras, known as the *Flota de Honduras*, would detach themselves from the New Spain-bound formation in this area. The rest of the convoy would shortly reach the Gulf of Mexico (Fig. 2-5).

Depending on the time of the year, the fleet followed one of two routes from San Antón to San Juan de Ulúa, in Veracruz. During wintertime the fleet navigated as far away from the coast as possible because of the frequent storms of the season. This route was known as *de afuera*, or outside route. The route used during the summertime was known as *de adentro*, or inside route. When using this route, the convoy sailed along the coast. In both cases, the navigation towards its final destination, the port of San Juan de Ulúa, Veracruz, took approximately eight days (Fig. 2-6).[30]

Departing La Deseada, the fleet bound to *Tierra Firme* continued its way towards the port of Santa Marta in Colombia. Many times the fleet did not stop at this point. However, the convoy continued on its way towards Cartagena de Indias by following the coast of what is today Colombia (Fig. 2-5). From la Deseada to Cartagena, the voyage lasted around ten days. The fleet stopped at Cartagena for only eight days and then headed towards Nombre de Dios.

For many years Nombre de Dios was the final destination of the *Tierra Firme* fleet. But the fact that its entrance channels were drying up and that the place had become highly unhygienic throughout the years of service to the fleets forced the Spanish government to direct the convoy to nearby Portobelo in 1593 (Fig. 2-7).

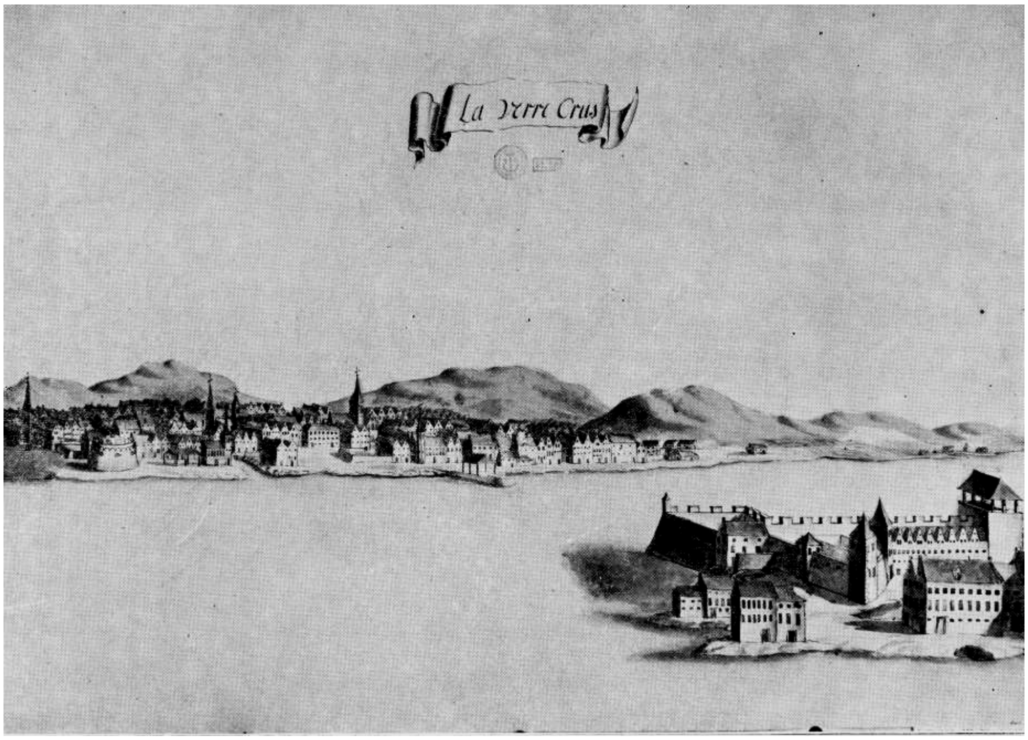

Figure 2- 6. Drawing of the city of Veracruz and the castle of San Juan de Ulúa.
(After Juárez 1972: Figure 2)

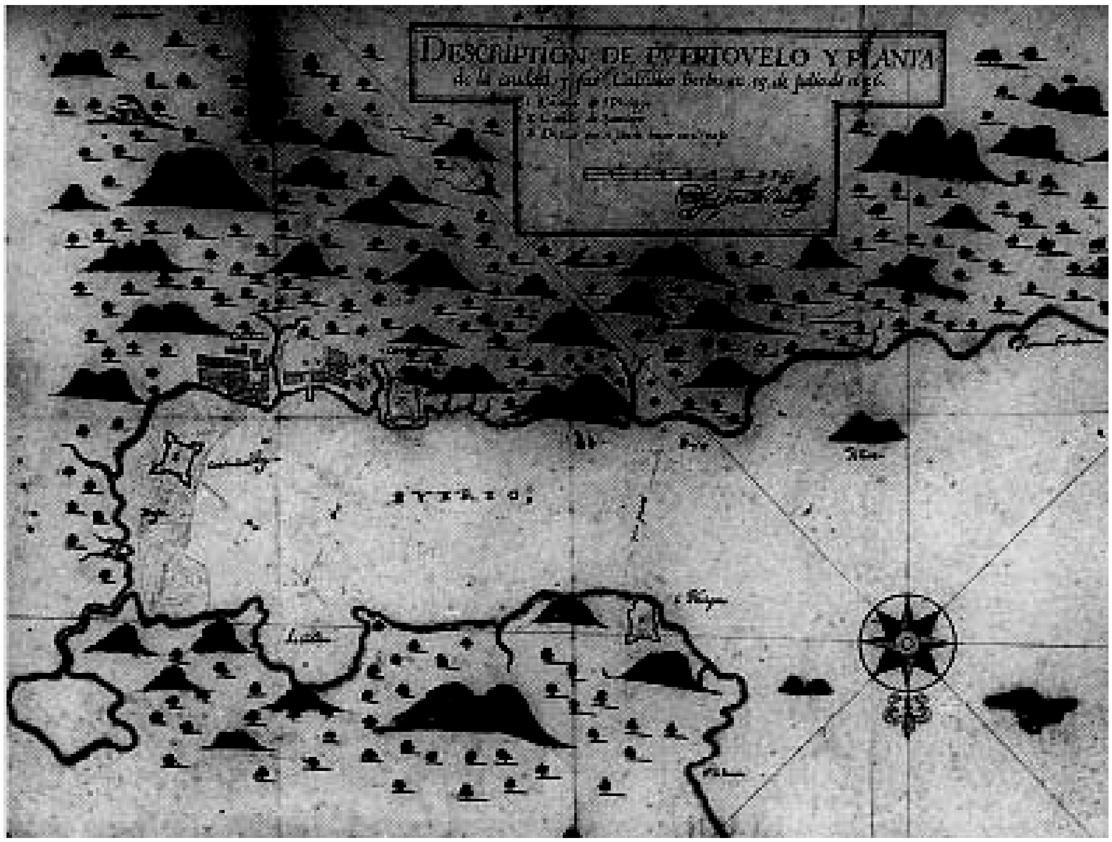

Figure 2- 7. Map of Portobelo Harbor in 1626. (After Ward 1993:93)

Later on, it was decided to move it again, and this time Cartagena was the chosen port (Fig. 2-8).[31]

The return voyage began from Havana, Cuba (Fig. 2-9). At this port, both fleets were to meet. To reach Havana the New Spain fleet departed from Veracruz and sailed northwest up to about 24 or 25 degrees latitude (Fig. 2-5). From that point the favorable winds would make it easy to reach the Cuban port. It took a fleet nine or ten day to reach Havana. The *Tierra Firme* convoy, on the other hand, had to sail for 15 days in order to reach Havana. Their voyage not only lasted longer, but it was more dangerous. In order to arrive at the Cuban port, the convoy had to go through the shallow areas of Roncador, Quitasueños, and La Serranilla along the coast of Panama (Fig 2-5). Once these shallows were left behind they sailed towards the Isla de Pinos, bordering the San Antón cape and then into Havana.

As soon as both fleets had arrived at Havana, preparations for the return voyage to the Iberian Peninsula began. When ready the fleets left Havana and headed for the peninsula of Florida. They then navigated into the Bahamas channel (Fig. 2-5). During summer, the fleets sailed northwest in order to reach 32 degrees of latitude. Once they had reached this latitude, they changed direction east one quarter of northwest until they reached 39 degrees of latitude. At this point, direction in navigation was defined within a system that started with the four cardinal points and was subdivided, sometimes by up to 32 different points.[32] During the winter the preferred route took them to the Bermuda Islands, and from there favorable winds allowed a north and northeast voyage to 37 degrees latitude. Either way, the fleets sailed past the Azores (Fig. 2-4). Often times they

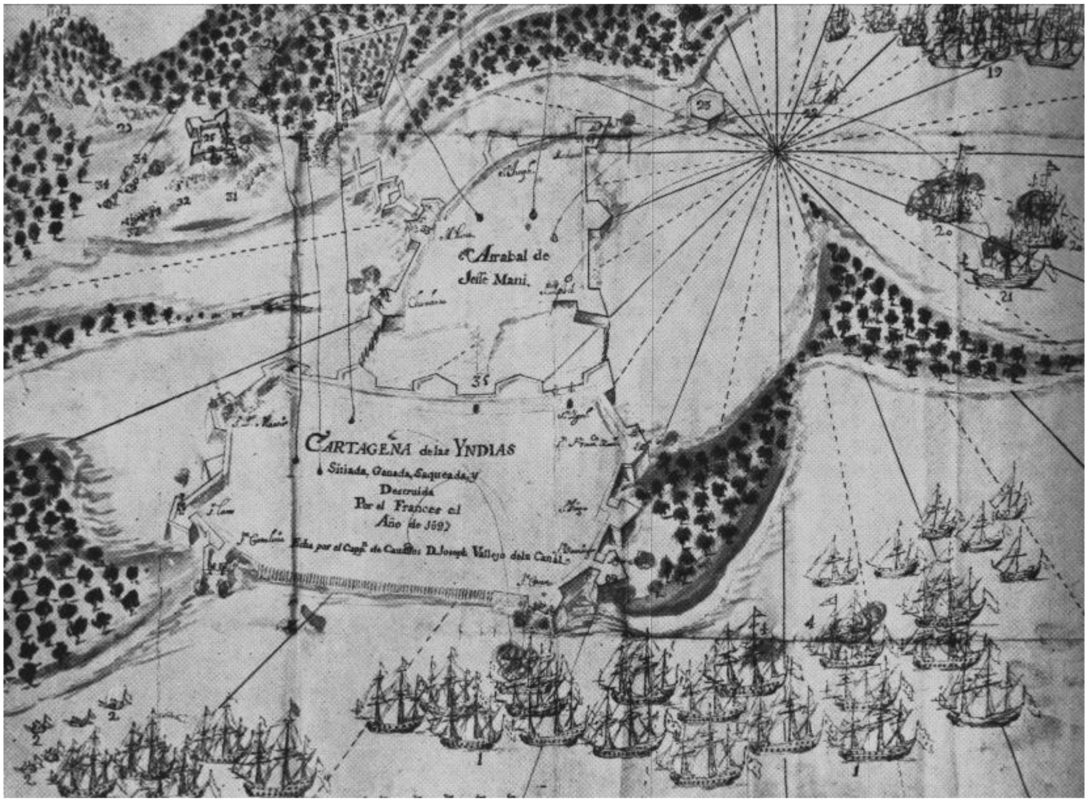

Figure 2- 8. Map of the city of Cartagena de Indias ca. 1692. (After de la Matta Rodriguez 1979: 94-95)

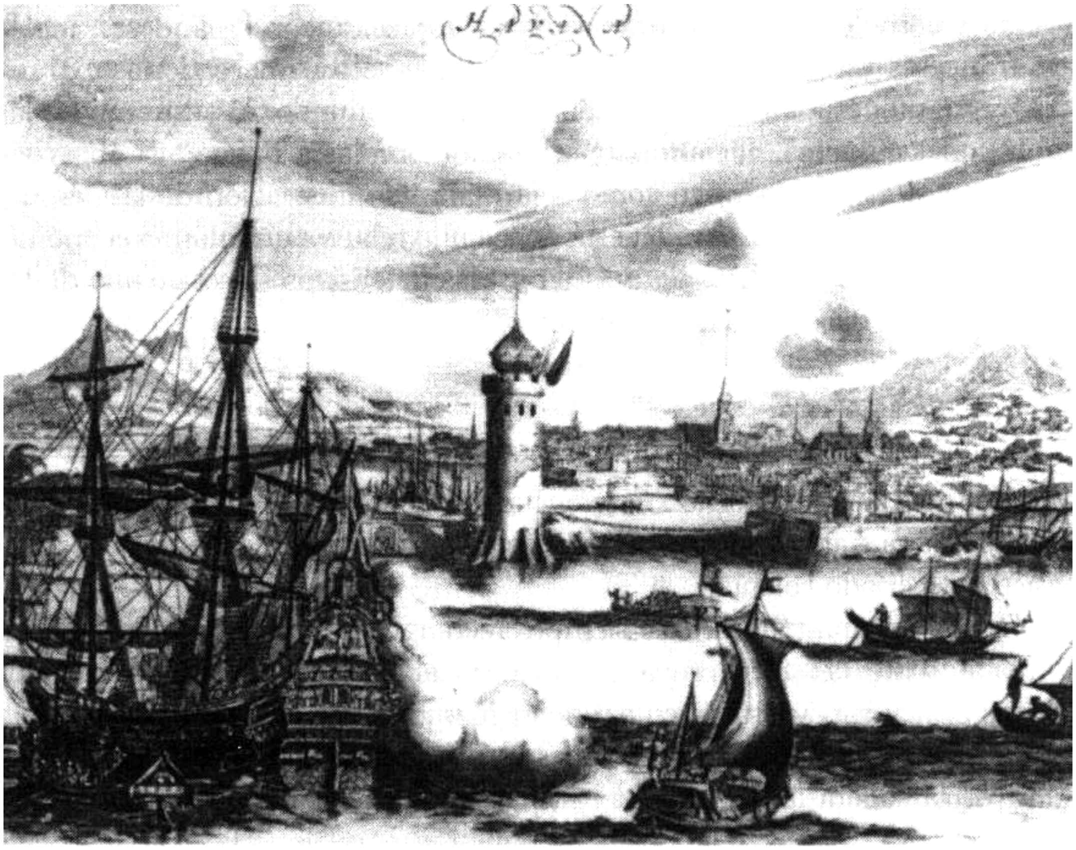

Figure 2- 9. Port of Havana in 1673 according to an anonymous Dutch engraving.
(After Capablanca 1998:19)

stopped on the south coast of Terceira Island (Fig. 2-10). Between 1580 and 1640 Portugal was under the rule of Spain and the fleets made a stop at the Portuguese Azores. Once the fleets had reached this part of the journey, a *patache* or messenger ship was sent from the island to the mainland to obtain information about the presence or absence of foes along the Iberian coast. From the Azores, the route continued toward the Cape of St. Vincent, and back to Sanlúcar de Barrameda. By then, the New Spain fleet had completed a return journey of 1, 400 leagues, or about 7,700 km, and the Tierra Firme fleet had completed a return journey of 1,700 leagues, or about 9,350 km.

The fleet system that came into use in the late 1530's had shown many advantages. A convoy that not only consisted of armed merchant vessels but that also included escorting warships made the long voyage to the Indies much safer. Also, by traveling in this manner, the costs of the *avería* were distinctly reduced. For this reason, it was decided that all commerce with the Indies should follow this system.

In any case, further regulation was required. In order for the crown to be able to assert better control over the system, the Indies trade had to be turned into a highly reliable and predictable arrangement. King Philip II (1556 - 1598) understood this. After consulting with the Council of the Indies and the *Casa de la Contratación*, he approved a set of laws in 1564 that instructed "every year two Fleets and a Royal *armada* should leave for the Indies."[33] The ordinances of 1564 also provided a permanent calendar for the departure of the fleets.

Pérez-Mallaína explains that many aspects had to be taken into consideration when choosing the right time for the departure of the convoys to the Indies. Navigating

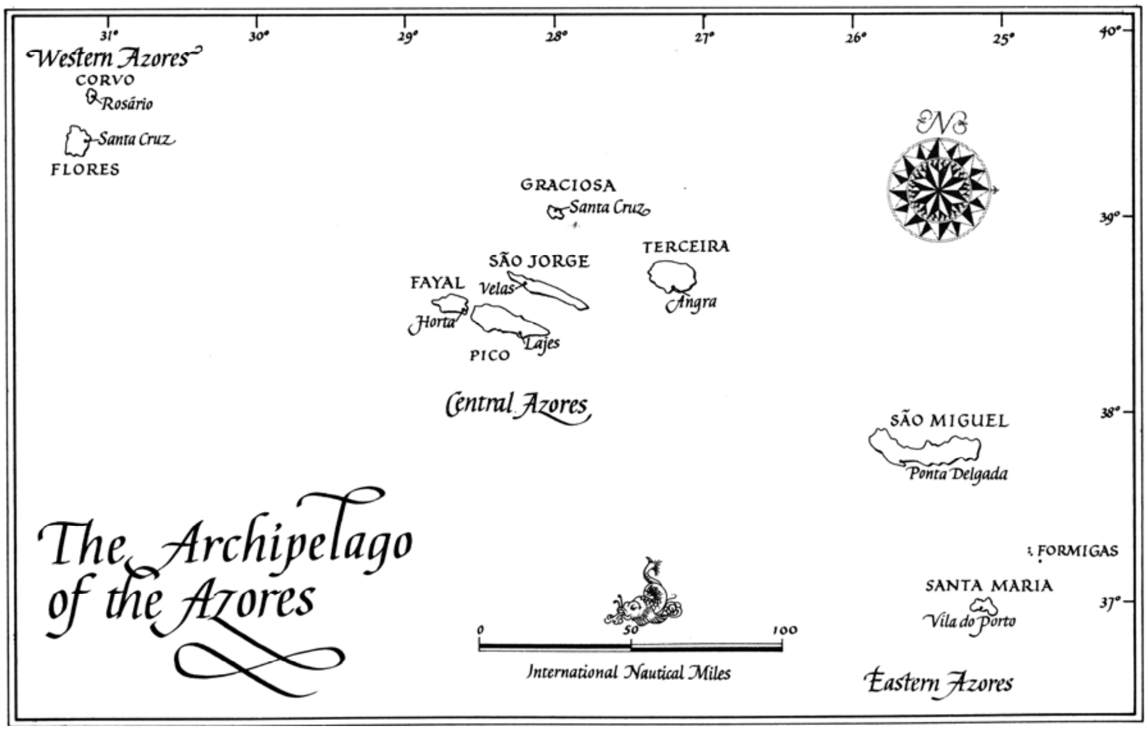

Figure 2- 10. Archipelago of the Azores. (After Duncan 1972:81)

during the winter exposed the fleets to the dangers of storms. In the summer the weather was more stable, but this was a far more active time for pirates. A second factor that had to be taken into account was that while it was summer in the Northern Hemisphere, in the Southern Hemisphere it was winter, and the storm season was at its peak.[34]

Having weighed all the factors, the Spanish crown decided that pirates were the lesser problem. It was therefore decided that the best seasons to dispatch the vessels were either spring or summer. The New Spain fleet was sent out between the months of April and May. This way the hurricane season would be avoided. The *Tierra Firme* fleet was sent out between the months of July and August, which would assure that the convoy would not arrive during storm season. For the return voyage, it was expected that both fleets leave Havana during the month of April to avoid, at any cost, reaching the Bahamas Channel during the hurricane season that began in August.

To further assure that the calendars were followed, regulation of navigation itineraries that included a full description of the routes to be taken, as well as the stops and their duration, was promulgated through a set of laws known as the *Instrucciones* of 1573 and 1597. Despite all regulations, the timing of the departure and arrival proved uncertain most of the time.

The Pacific Routes

During the 1540's, silver mines were discovered in Potosí, Peru. At first the silver output was low, but production flourished after the implementation of the mercury amalgam process, a technique that involves the isolation of silver from waste by combining it with mercury.[35] The Potosí mines became the primary suppliers of silver for the empire, and during the 1580-1650 period the revenue obtained from the mines was always higher than 7.6 million pesos annually.[36]

Silver traffic was conducted through the ports of Peru in the Pacific Ocean. A convoy carrying the silver would leave the port of Callao, near the city of Lima. Approximately three weeks later, the silver galleons arrived on Panama's Pacific Coast (Fig. 2-4). From there the silver was transported across the isthmus to the Atlantic coast where the valuable metal was loaded into the vessels of the *Tierra Firme* fleet and transported back to Spain.

The silver convoy would then return from Panama to Callao. This return voyage was one of the longest voyages undertaken in the Indies trade system. Because of the opposing winds and currents, it could take up to 5 months for the fleet to arrive back at Callao.

A brief paragraph is now needed to discuss the connection between the Indies trade and the Asian trade. Asia would represent the last frontier for the Spanish Empire. During the early 16th century, the Portuguese successfully established trading posts at Goa and other forts around the rim of the Indian Ocean, and in the Spice Islands of Southeast Asia. Spain, not wanting to be left out in the profitable trade of spices and other valuable Asian commodities, sent several expeditions to the Far East.

Because of the prohibitions of the Treaty of Tordesillas, Spanish explorers were not allowed to sail down the African coast, around the Cape of Good Hope, and into the

Indian Ocean. The treaty, signed by the Spanish and Portuguese monarchies in 1494 and ratified by Pope Julius II in 1506, divided the newly discovered lands outside Europe exclusively between the Spanish and the Portuguese along a north-south meridian 370 leagues (2,000 km) west of the Cape Verde islands (meridian 46º 35'). The anti-meridian to the line of demarcation stipulated in the Treaty of Tordesillas was specified a few decades later by the Treaty of Zaragoza, signed in 1529 (Fig 2-11).

In order to reach Asia, the Spaniards took advantage of their colonies in the New World and ventured westward across the Pacific Ocean to the South China Sea. In 1542, after several failures, an expedition that departed from the port of Navidad, Mexico, reached an archipelago near the coast of China.[37] These islands, discovered by Fernão de Magalhães in 1521, were named the Philippines in honor of the future King of Spain Philip II. Throughout the next three centuries, the Philippines functioned as Spain's main colony and trading outpost with Asia.

From the year 1565 and onwards, a small convoy consisting of two to four vessels, known as the Manila Galleons, sailed every year across the Pacific Ocean. The galleons sailed out of the port of Acapulco in Mexico. From Acapulco, the route descended to 15 degrees latitude. Then, the convoy changed directions and traveled west following a straight line between the tenth and the fourteenth parallel until it approached the Ladrones Islands, known today as Mariana Islands. The route then rose up to 13 degrees latitude. Following that latitude the convoy reached the island of Guam. From there, the galleons arrived at the Philippines in a few days (Fig. 2-4).[38]

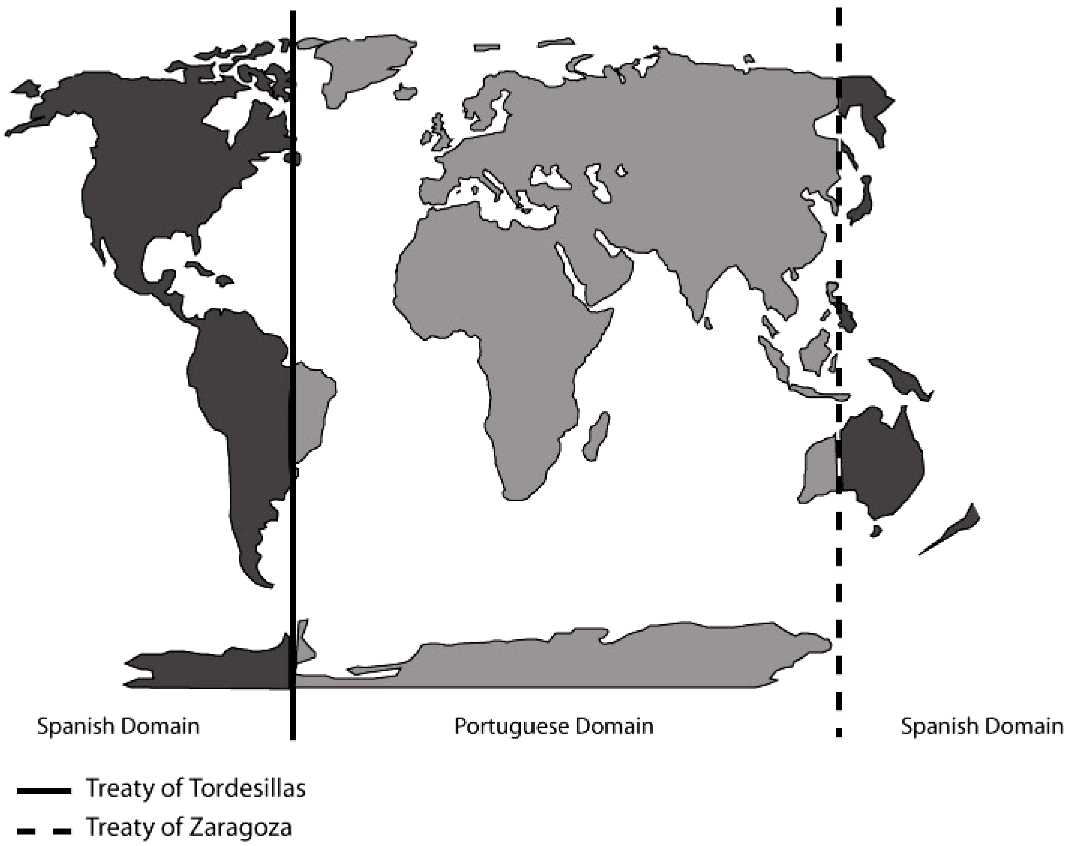

Figure 2- 11. Lines of demarcation stipulated by the treatises of Tordesillas and Zaragoza.

On the return voyage the galleons traveled north to 40 degrees in latitude, and then followed the Kuro Shivo current along that parallel. This current would take them to the coast of California, and thence to Mexico and the port of Acapulco (Fig. 2-4). On the return voyage, the crews of the Manila Galleons would endure the longest of all the open-ocean journeys traveled by the Spaniards, for it lasted up to five continuous months.

The Manila Galleons also acted under strict regulation of the crown. In 1593, Philip II ordered that only two galleons could make the Pacific journey each year, and limited the tonnage of each galleon to 300 tons.[39] As was the case with many other regulations passed by the monarchy, the tonnage rule was never truly enforced. By 1589 some of the vessels in the Asian trade had reached 700 tons, and by the second decade of the 17th century galleons of 1,000 tons were being used.[40]

Through the same ordinance of 1593, the galleons of the Manila fleet began to be supported at royal expense. The policy was a subject of great debate throughout the late 16th and early 17th century. On the one hand, the supporters of the policy argued that private ownership of the fleet would raise the freight rates too high. On the other hand, those against the policy often referred the great coasts to the king as the main reason for turning over the fleet to private ownership of vessels. In 1596 the fleet’s cost was valued at 150,000 pesos above the revenue obtained from the freight, and in 1607 the loss was 130,000 pesos. In the end, private ownership could not compete with the subsidized galleons, giving way entirely to royal ownership.[41]

The Armadas of Philip II

In 1493 Rodrigo Borgia, the Spanish-born Pope Alexander VI (1492-1503), granted the Spanish monarchy the rights of colonization and evangelization of Columbus's' newly discovered territories, as well as of any new land that was discovered from that point on. The Portuguese King John II (1481-1495) complained about the decision, considering this an excessive privilege for the Spanish crown. After reaching an agreement with the Spanish monarchs, the world was divided between the two Catholic monarchies through the Treaty of Tordesillas, mentioned earlier in this chapter.

With the advent of the Protestant Reformation came the questioning of such division of the world. The new Protestant nations no longer submitted to the authority of the Pope. Consequently, they no longer adhered to the Treaty of Tordesillas, a situation that gave way to a wave of piracy in the Spanish-ruled Atlantic Ocean.

During the reign of Philip II, the Spanish monopolistic control of the Indies trade would be constantly threatened by other European nations. In 1558, Queen Elizabeth I (1558-1603) ascended to the throne of England. Supported by their new protestant queen, English corsairs began to make their presence known in the Indies during the 1560's. It was also during this decade that a full-scale Protestant revolt exploded in the Spanish Netherlands, forcing the Spanish crown to concentrate military resources in this area. Philip II would have to depend more than ever on the treasure and revenue obtained from the Indies to finance his campaigns in the Dutch Provinces.

As a result of the new outburst of piracy it became necessary to establish a reliable system of defense in the Atlantic. During the first two decades of the 16th century, the defense of the Atlantic was mainly carried out by vessels intended for merchant traffic that carried artillery and were supplemented with companies of soldiers. Between the 1520's and the 1570's the Atlantic passages were protected by *armadas* that were created on an *ad hoc* basis and were funded by the *avería*. These consisted of two vessels on average, and were organized to protect specific geographical areas.[42] It was not until the last decades of the 16th century that permanent *armadas* were created in order to recapture control over the Atlantic.

The first of these *armadas*, the *Armada Real de la Guarda de la Carrera*, was created in 1567. Its main purpose was to guard inter-oceanic traffic and permanently protect the West Indies. The *Armada Real de la Guarda de la Carrera* was the first to be fully funded by the crown. With the creation of this armada the protection of the Indies was now accomplished through an *armada* entirely financed by the Spanish crown in conjunction with the *armadas* that were funded through the *avería*.[43]

In 1580 the Portuguese crown fell into Philip II's hands, and Spain took possession of the Portuguese empire and trade networks in Asia, worsening the already growing tensions between the Catholics and the Protestants. The *armadas*, which up to this date had been in charge of protecting specific geographical areas, were incorporated into a new *Armada del Mar Océano.*[44] Through this action, the *armada* was expected to assist in the protection of the Indies, the routes of the *Carrera de Indias*, and the Atlantic coasts of Spain. The fleet was divided into three operating squadrons.[45] The first was based in Lisbon and charged with the protection of the coast from Cape St. Vincent to Cape Finisterre. This squadron would also sail to the Azores to escort the homeward-bound ships of the *flotas*. The second squadron was based in Cádiz and was charged with defending the Strait of Gibraltar. The third squadron was based at La Coruña and charged with patrolling the north coast of the Iberian Peninsula to secure that area against Dutch attacks. To fund this permanent structure Philip turned to the *Consejo de Indias*. In 1590, the *Consejo* agreed to provide 8 million ducats over a six-year period to maintain the Atlantic *armada*.[46]

Besides the protection of the Atlantic, the crown also had to constantly worry about the protection of the Caribbean and Pacific Ocean routes. For the Caribbean, discussions over the creation of a permanent *armada* to patrol the Antilles and the Indies' coasts began around the last decade of the 16th century.[47] Its main task was counteracting the increasing Dutch attacks at the salt pan of Araya, on the coast of Venezuela, and protecting the *Tierra Firme* fleets as they sailed through the Caribbean on their return voyage to Spain, assuring that the large amounts of silver obtained from Peru reached Seville safely. The result of the discussions was the creation of the first *Armada de Barlovento* in 1601, which consisted of eight galleons and four *pataches*. In that year this *armada* sailed too late in the spring and was thus unable to carry out its orders. It was dismantled only a few years later due to its doubtful usefulness in securing the Caribbean region, and Spain's shortage of funds.[48] It is not until 1641, after an Anglo-Portuguese alliance managed to trigger the independence of Portugal, which became an English ally, that the *Armada de Barlovento* resumed its functions.

Regarding the protection of the Peruvian Pacific coasts, a system known as the *Armada del Mar del Sur* was created after the attacks that Sir Francis Drake, the celebrated English pirate, conducted on the Pacific coasts in 1578.[49] The only function of this *armada* was safeguarding the silver galleons that each year traveled from Callao to the Panamanian Isthmus.

One last episode of history that took place during Philip II's reign and must be mentioned in regard to the Indies trade is the 1588 Spanish Armada disaster. Historians Casado Soto and de Solano have studied the effects of the Spanish Armada failure in the English Channel on the commerce of the Spaniards with the Indies. Both concluded that while this event was a blow to "the prestige of Spain and to its political and religious leadership" it did not "suppose the start of crisis or of decadence".[50] Casado Soto further adds that:

> Spanish naval power maintained its hegemony over the most important routes, and indeed increased its domination mainly because of the large increase in shipbuilding both for commerce and war and to the permanent squadrons already in existence, such as the ones for the Atlantic Ocean, the Indies trade convoys, and the Caribbean and the Pacific.[51]

Philip III's Shipbuilding Policies

The reign of Philip III (1598-1621) was characterized by a period of peace with Spain's European neighbors and main opponents of the Spanish monopoly in the New World. In 1598 peace was accorded with France. Six years later, in 1604, peace was made with England, and by 1609 a truce was settled with the Northern Netherlands.

However, peace would not deter French, English, and Dutch corsairs from attacking the fleets and ports of the Spanish Indies. The Spanish crown made it clear that it intended to enforce its monopoly over the Indies traffic, and Philip III continued to implement policies to assure the proper protection of its colonies.[52]

Among the policies that the crown adopted to enhance Spanish naval power was closer regulation of the shipbuilding industry. During the 16th century, the crown encouraged the production of vessels that could serve both as merchant ships and as warships. Throughout that century, the monarchy established a system for leasing private vessels and incorporating them into the *armada*s that protected the Indies.

The ship leasing policies were never favored by merchants, who in many cases were never paid in full by the crown for their leasing services. Towards the end of the 16th century, Spanish private shipbuilding was also declining, making it harder for the crown to continue hiring private vessels. At the same time, warship design had become more specialized throughout Europe, rendering the merchant vessels less appropriate for naval service under the Spanish crown.

Philip III understood that the decline in shipbuilding was a threat to the empire. As a result, during the early 17th century, he opted to subsidize private shipbuilding in order to enhance the industry. He also favored hiring private shipbuilders who would work under the rule of the monarchy.[53]

The king was also confronted with the pressing necessity of establishing a precise system for measuring ships. The main reason was that “the subsidies for naval construction, the payment of wages to embargo ships, the custom dues on Indian commerce and maintenance of its monopoly, even the security measures decreed for commerce with the New World, were all based on the tonnage of a ship."[54]

One way in which Philip III addressed this necessity was through the standardization of ship measurements. In 1607, the first of three *ordenanzas para la fábrica de navíos de guerra y mercantes* (ordinances for the construction of war and merchant ships) was issued, aimed at regularizing the sizes and configurations of the ships that were to take part in the Indies trade and protection. This first set of regulations was perfected and completed by another two ordinances. The second was passed in 1613 and served as a revision of the measurements and shipbuilding standards of the 1607 ordinances. The third set was published in 1618, again intended to improve the 1613 establishments. The publication of the 1618 ordinances marked the end of Philip III's major naval legislations.

When King Philip III died in 1621 the economic problems that had plagued the empire were increasing rapidly. During the 1620's the Spanish empire sank into a serious economic depression, worsened by a new period of hostilities with Spain's old enemies. The empire was forced to resume its crusades against the aspiring English and Dutch Protestant powers. Starting in the 1630's and up to the 1640's the Thirty Years War occupied the Spanish armies on every front. Although Spain was able to retain a major share of the West Indies trade, by the end of the 1640's Spain had lost its New World monopoly and held an increasingly secondary role in European politics.

Throughout the 16th century Spain was able to maintain one of the largest empires of modern history through a meticulous system of maritime communications that united the Spanish Iberian Peninsula with its colonies in the New World and Asia. During that century Spain became the most active trading nation in Europe. This status was lost during the 17th century, but commerce endured despite several bankruptcies and economic depressions, which plagued the Spanish Empire after the early 17th century. The communication and trade systems that were established in the 16th century continued to operate at functional levels until the fall of the empire in the 19th century.

Part of this success was owed to the great capabilities of the empire in adapting to political, economical and social changes. Another part of this success was owed to its ability to regulate and standardize the many different aspects of the *Carrera de Indias*.

With the foundation of the *Casa de la Contratación*, the Spanish crown established an organization that generated control of the commercial and defensive aspects of the *Carrera*. By establishing the *Casa* in Seville and by making this city the European terminus of the *Carrera*, the crown managed to concentrate the power in one area, and thus made it easier to keep the Indies trade under strict vigilance and control.

The creation of the fleet and *armada* systems proved advantageous to securing trade from European enemies that tried to break the Spanish monopoly. Also, by carefully regulating the routes which the fleets had to follow after their departure from Seville and the calendars by which the fleets sailed, the crown managed to transform the trade of the Indies into a regular and reliable source of income.

One last aspect to be taken into account is that if Spain had not possessed the necessary seamanship, armament, and shipbuilding technology it would have never achieved the enormous success it did during the greatest part of four consecutive centuries, between 1500 and 1900.

During the reign of Charles I of Spain an attempt was made to standardize the numbers of the crews, as well as the quantity of ammunition and armament that should be on every vessel traveling to the New World. This effort was intended to better protect the vessels on their voyage through the Atlantic.

In spite of the frequent Anglo-Saxon accounts of incompetence and corruption, the Spanish bureaucracy worked very well. The regulations for the standardization of ships were especially important in two particular ways. First, they granted the crown a closer control over the volume of merchandise that was transported through the Spanish sea routes. This meant that the crown was able to obtain the proper custom dues on Indian commerce and to control the *avería* used in the protection of the trade. Second, it opened a new era in Spanish ship design.

ENDNOTES CHAPTER II

[1] Casado Soto 1990, 95

[2] Phillips 1986, 86

[3] Kamen 2003, 42

[4] McAlister 1984, 92

[5] Castillo Juárez 1997, 18

[6] Ibid, 19

[7] Fisher 1997, 47

[8] Chaunu 1955, 2: 6-7

[9] Ibid, 8-9

[10] Ibid, 20-1

[11] Ibid, 112-5

[12] Castillo Juárez 1997, 25

[13] Kamen 2003, 98

[14] Ibid, 105

[15] Ibid, 109

[16] McAlister 1984, 234

[17] Ibid, 234.

[18] Phillips 1986, 9

[19] Fernandez Duro 1972, 1:204

[20] Castillo Juárez 1997, 27

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[21] For a full transcript on these regulations see Spain 1943, Book IX Title XXX Law XXX, 382

[22] McAlister 1984, 201

[23] Fisher 1926, 17

[24] Pérez-Mallaína 1992, 13

[25] Pérez-Mallaína 1992, 18

[26] Castillo Juárez 1997, 238

[27] Morales Padron 1955, 288

[28] Castillo Juárez 1992, 235

[29] Ibid, pg 239

[30] Ibid, 241

[31] Ibid, 242

[32] Ibid, 244.

[33] Spain 1943, Book IX Title XXX Law I, 374

[34] Pérez-Mallaína 1992, 19

[35] Kamen 2003, 285

[36] Ibid, 285.

[37] Schurz 1959, 21

[38] Ibid, 246

[39] Ibid, 193

[40] Ibid, 194

[41] Ibid, 199-200

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[42] Cerezo Martínez 1988, 162

[43] Castillo Juárez 1997, 51

[44] Cerezo Martínez 1988, 166

[45] Goodman 1997, 9

[46] Ibid, 8

[47] Torres Ramirez 1981, 2

[48] Sluiter 1948, 185

[49] Cerezo Martínez 1988, 181

[50] de Solano 1993, 78

[51] Casado Soto 1998, 125

[52] Phillips 1986, 17

[53] Ibid, 20

[54] Casado Soto 1988, 105

CHAPTER III

SPANISH SHIPBUILDING DURING THE LATE 16th AND EARLY 17th CENTURIES

During the Middle Ages, two main shipbuilding traditions prevailed in Europe: the Northern European tradition and the Mediterranean tradition. Up to the late Middle Ages, Northern European vessels were built with overlapping strakes, either nailed or riveted, and reinforced with an internal structure. The hull was assembled by placing a central keel or keel plank and generally curved stem and stern posts. The inner hull was reinforced with light, evenly-spaced frames.[1]

In the Mediterranean, shipbuilding gradually developed from the more labor-intensive and material-wasteful process of shell-first construction to a skeleton-based construction method. Between the fifth and tenth centuries, shipbuilders slowly departed from a longitudinal conception of the hull in which the longitudinal shapes of the planks were used to control the desired transverse curvatures. Instead, the hull started to be conceived in a transversal manner. The frames of the vessel became the decisive factor for the shape of the hull.[2]

In skeleton-first construction, a pre-designed master frame was erected at the widest section of the hull. Two tail frames, also pre-designed, were then fastened to the keel at a specific distance, sometimes calculated by perpendiculars dropped at a certain distance from the heads of the stem and stern posts, creating the “box” of the hull. The remaining frames were then narrowed and raised using simple geometrical algorithms calculated in relation to the bottom of the master frame. Longitudinal control was then exerted with ribbands bent at different levels over the central section created by the frames.[3] As noted by historian Frederic Lane, “the heart of the shipwright’s ‘mystery’ laid in the determination on the main proportions of the ship and the shaping of the curves of the ribbed frame work.”[4] Two surviving Venetian manuscripts dated to the fifteenth century provide an insight as to how this process was done. The first of these manuscripts, the *Fabrica di galere* or *Livro di marineria*, has been dated to 1436 and attributed to Michele da Rodi, an *armiraio* of the Venetian Arsenal.[5] The second manuscript, dated to about 1445, consists of the notes of Georgio Trombetta, a Venetian merchant, and is known as the Timbotta or Trombetta manuscript. The texts recorded proportions for the design of galleys and round ships, a number of proportional methods for pre-designing the central frames of the vessel, and ways to calculate the narrowing and rising of the bottom of the frames (Fig 3-1). According to illustrations included in the manuscripts, the curvature of the master frame was established by creating intervals at distances of ½ *piedi* (approx. 17 cm) or 1 *piedi* (approx. 35 cm) above the floor. Proportional lines, parallel to the floor, marked the different widths of the frame at the designated intervals. Similar proportions would have been used for determining the shape of the tail frames. As for the narrowing and the rising of the frames, two methods were described on these manuscripts and explained 150 years later by Neapolitan writer Bartolomeo Cresencio in his *Nautica Mediterranea*. The first is known as the *mezzaluna* method. The second is known as the *triangle* method.[6]

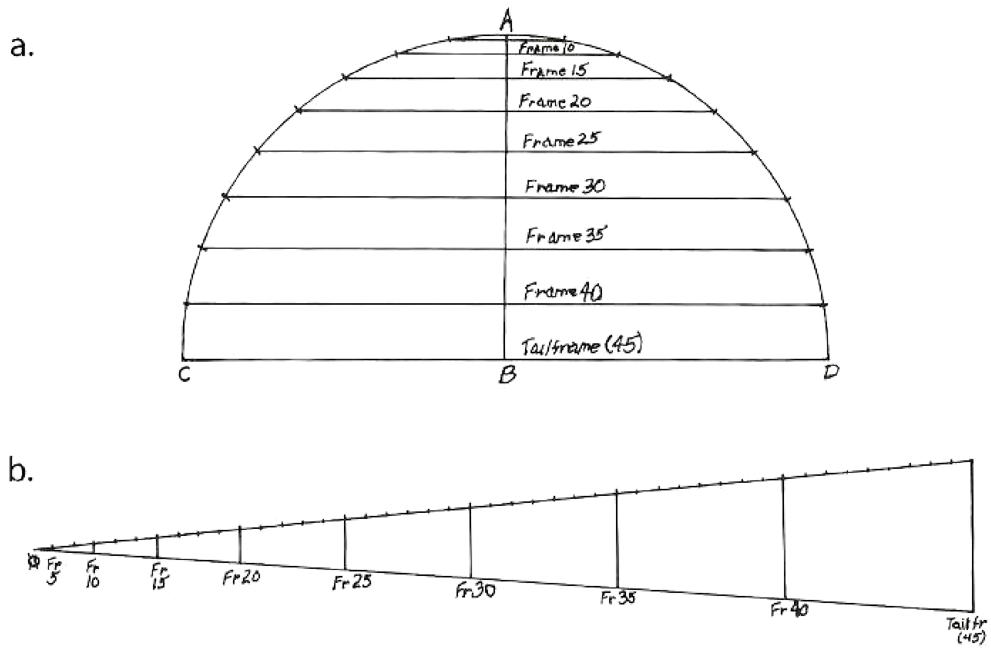

Figure 3- 1. Proportional methods used for pre-designing the central frames of the vessel: a) *mezzaluna* b) *triangle*. (After Steffy 1994, 98)

Italian shipbuilders applied predetermined and simple proportions to obtain the basic hull dimensions. The beam functioned as the key element in the design from which the length of the keel, the dimensions of the stem and sternposts, the depth in hold, the flat portion of the floor timber of the master frame, and even the sizes of the masts, cables, and anchors were obtained. It is important to note that not all necessary measurements could be obtained by using proportions. Still, shipbuilders of the period continuously attempted to find standard proportions between the different measures in order to obtain a set of principles of design that could be applied when building vessels of the same type but of different dimensions.[7]

A variation of the Mediterranean tradition, the Iberian tradition, may be added to the European shipbuilding philosophies. The Iberian Peninsula was situated in a strategic position between Northern Europe and the Mediterranean, the two great areas of European shipbuilding development. For many centuries before Columbus, the seamen, shipbuilders, merchants and ship owners of the Iberian Peninsula were exposed to all types of ships that sailed by, and consequently incorporated useful designs into their vessels.[8] As a result, Spanish and Portuguese ship design combined characteristics from Northern and Southern Europe and from the Islamic world.[9]

After 1492, Spain became the cross road between Europe and the Atlantic. Though still greatly influenced by Mediterranean shipbuilding technologies, Spanish shipbuilders had to adapt the round ship design to meet the demands of the Atlantic Ocean. Atlantic Ocean seafaring was more demanding from the structural point of view than the Mediterranean.[10] Hulls had to be stronger to withstand the severe weather conditions. Also taken into consideration was the protection of the vessels from the warm waters of the Caribbean, where teredo worm attacks were especially vicious.

At the same time the navigation patterns changed from coastal trade to sailing the open ocean. This meant longer distances traveled and fewer possible stops. More space in the hold for provisions, along with space to accommodate people and merchandise were now required, calling for roomier, stronger and faster vessels.[11]

Typology of the Spanish Ships

The Spanish fleets were roughly organized into three functional groups: fishing fleets, commercial fleets and those dedicated to warfare. Complementing these were the New World *armadas* and the exploration and colonization fleets. Each fleet was assembled by ships of a specific typology, even if most vessels could be used for more than one function.[12]

From the Early Middle Ages fishing fleets were sent to the seas of Ireland, France and Morocco. Ships used on such ventures included *bateles* and *barquias, chalupas* and *galeones abiertos, pinazas, chalupas con cubierta, zabras,* and *carabelas*. By the mid-16th century, cod and whaling expeditions to Newfoundland involved merchant galleons and *naos*.[13]

Large scale commercial fleets covered both the *carreras* of Flanders, France and England, Andalusia, the Mediterranean, and the Indies trade. Both fleets incorporated medium and large-sized ships; from smaller to larger, *carabelas*, *navíos*, *galeones*, and *naos,* and in some cases carracks, an Italian designation for merchantmen that is difficult to differentiate from the Spanish *naos*.[14]

In regards to warfare, the Mediterranean area has to be set apart from the Atlantic area. On the Mediterranean war fleets relied on two kinds of ships: galleys and small oared vessels: *saetías, bergantines,* and *fragatas*, among others, as well as the ships from the Atlantic front, such as Cantabrian *naos*, *carabelas*, and *chalupas abiertas*. On the Atlantic, the defense of the merchant fleets was done through the use of small, well-armed squadrons. As privateer activity increased starting at the mid-16th century, larger ships of new design were added to the squadrons of *carabelas* and *zabras*, namely *galeones* and *galeazas*. By the end of the century, new prototypes of galleons as well as *galizabras* and *fragatas mancas* were added to permanent squadrons.[15]

In the treatise *Norte de la contratación de las Indias Occidentales*, written in 1688, José de Veitia Linage provides a typology of the vessels built by the Spanish and by other European nations throughout the 16th and 17th centuries that helps the further understanding of the Spanish ships' diversity, but does not clarify the individual characteristics of each type. Veitia defined "Ship" the following way: [16]

- *Nave, Nao o Navío* (Ship): are high board vessel of much capacity and strong enough to withstand the tempests, the waves, and to confront the enemies and defend from them. Having explained that *Nave, Nao o Navío* all mean the same thing, the *Galeones* are the chief type of *Nao* for the *Carrera de Indias* (Fig. 3-2). It is important to know that there are three types of *Naos* built in Spain, some of two decks, which earlier, (and even in our times), were favored for war, others of one deck, which can only be built as small vessels, and others of three decks, known as *de Puente corrida* which are now most used and in repute.

Then, under the category of *Naos*, Veitia classified the following vessels:[17]

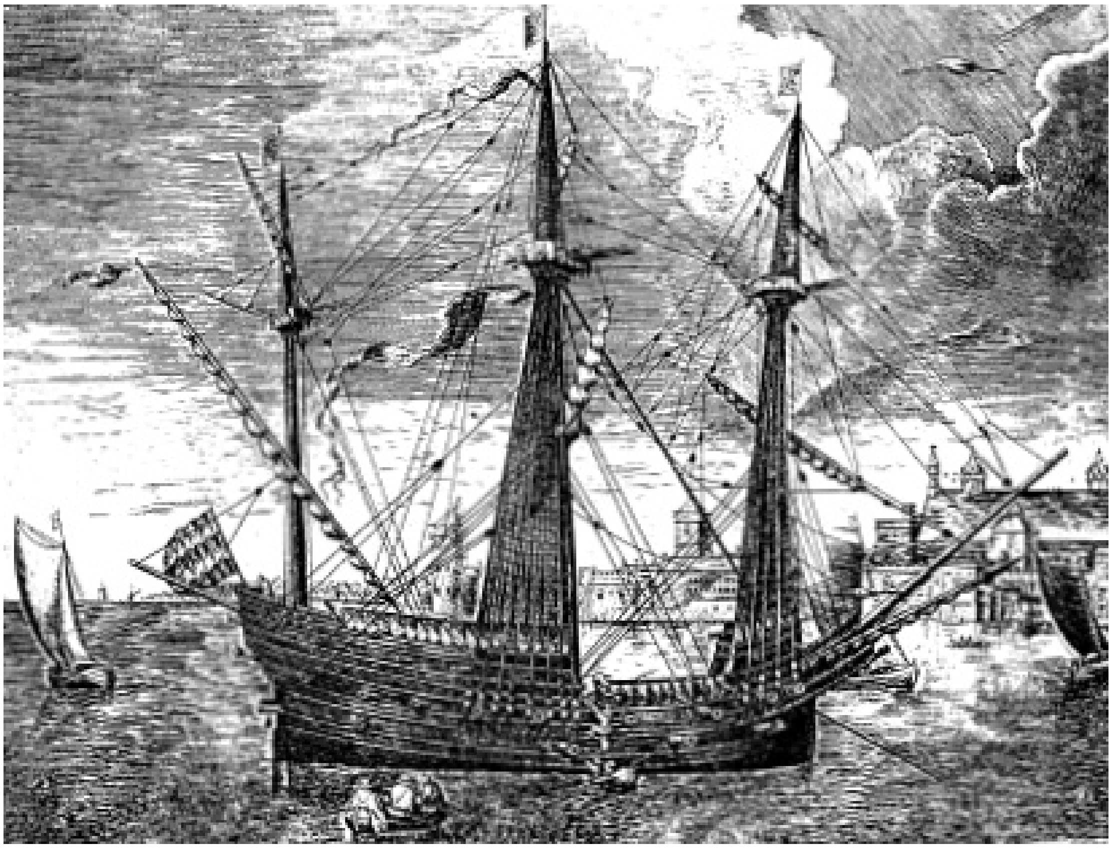

Figure 3- 2. Engraving of an armed *nao* by Franz Huis based on the work by Brueghel The Elder, 1550-60. (After Casado Soto 2001, 151)

- *Urcas:* are low, flat-bottomed vessels of foreign design, which generally lack strength and fortitude.

- *Fragata*: are long vessels, both of Spanish and of foreign construction, built for war, after the modern manner.

- *Pinques y Felibotes*: are two decked vessels that are not square sterned but have a sternpost like the stem post, this being the reason why they are called double-ended vessels. They are flat-bottomed and with little depth of hold, and so they are only good at overcoming the risks of sandbars and shallows. In everything else they are vessels of little defense for war and bad to govern in storms.

- *Carracas*: are the large ships, of meticulous navigation, used by the Portuguese in the voyages to India.

- *Pataches*: is a generic name for the small vessels taken by an *armada* to delegate orders, probe for shallows, and to do other tasks as commanded by the Admiral.

- *Saetis, Carabelas, Polacas (o Pollarca), Flautas, Tartanas, y Galizabras:* are vessels used in the Levant, lateen-rigged, of 100 tons, give or take, it being rare that they exceed 200 tons. And as for *Tartanas*, they are commonly of 40 to 70 tons.

- *Galera* (Galleys): are the oldest and best known vessels in Spain.

- *Galeazas*: (formerly known as *Mahonas*): are composites of the galley and a high-board ship, just as much a *Vergantin* like a galley, but galleasses may reach up to 700 tons, and can carry 60 guns, and 1,500 men, and have the same sails of a galleon.

- *Carabelas de Túnez*: carry 40 guns, have round sails, and reach up to 300 tons.

- *Barcos*: are of different types, some of topmast with topsails, of which the largest are known as *Gavarras*, some of 150 *pipas*, and the smallest, *Barcos otorgados*, that are of medium size, in between the *Gavarras,* and the *Barcos luengos*, being the latter the lighter vessels that have been created.

- *Pinzas*: used in Biscay, are of the tonnage of the *Gavarras* of Seville, but with some differences in construction, and not as large.

- *Zabras*: are also used in the Biscay area, nowadays in lesser use since they were the 100-to 200-ton vessels, used for fishing, and privateering, being for both, although now more common to use frigates.

- *Tartanas*: carry as much as the *barcos otorgados*, are lateen-rigged, used in the Levant, being very useful for fishing, and some have been used as messenger ships to the Indies, and have been successful in their navigation, even though it is necessary to allow three or four foreign sailors to handle the rigging, because the Spanish do not understand how to control it.

- *Balandras*: are vessels used by the English, of the tonnage of a *Gavarra*, but swifter, which have a mainmast, and bowsprit, but no fore-mast, and are very sturdy.[18]

- *Lanchas, Esquifes or Botes*: small vessels carried by the *naos* to transfer from one vessel to another at sea, and to reach land at the ports.

As this document indicates, the galleon was the merchantman and warship of the Indies trade during the 16th and 17th century. Its origin and evolution are unclear, but by the late 16th century the Spanish galleon had developed into its best renowned form, which included: a high aft castle, a flat stern, a low, set-back forecastle, a beak below the bowsprit, and a full ship rig (Fig 3-3).[19] By the second half of the 17th century, the aft superstructures were reduced in size, and those of the bow had almost disappeared; making the galleon design more like that of a later frigate (Fig 3-4).[20] The change occurred as a response to the evolution of the ship of the line gradually developed by England, France, and Holland during this period.

Throughout its lifespan, a galleon could serve as part of a merchant fleet, as its *Capitana* or *Almiranta*, or could be called into the service of the *armadas* that protected

Figure 3- 3. *Galeón de Utrera* ca. 1550. Replica, made in 1931, of the model found at the *Santuario de Nuestra Señora de la Consolación de Utrera*, Seville. (After Moliné Escalona [2006, January 06])

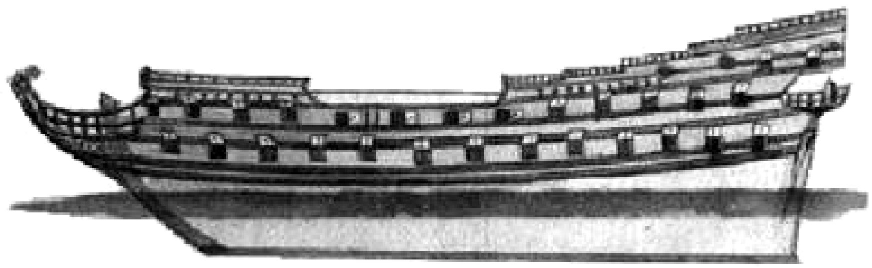

Figure 3- 4. Side view of a 17th century Spanish galleon by Juan José Navarro, Marqués de la Victoria. (After Victoria 1995, folio 5)

the fleets.[21] The galleon thus functioned as a multipurpose vessel, as this notion of a multipurpose vessel was not uncommon during the 16th century. The classic compromise was the armed merchantman. In many cases, the speed and maneuverability of the warship was sacrificed to increase the vessel's cargo carrying capacity.

According to Veitia, three types of galleons predominated in the Indies trade. [22] The one-decked galleon, sometimes referred to as a *Galeoncete,* was a ship of smaller dimensions fit for short sea trade. The two-decked galleon, also known as *Galeón de pozo*, was preferred for war purposes. The galleons of the *Armada del Mar Océano* fitted into this category. The three-decked galleon was the type preferred for the Indies trade. The main differences in the design of the *Armada del Mar Océano* galleons and those serving the *Carrera* were based on their functions. The galleons of the *Armada* were meant to patrol the coasts of the Iberian Peninsula and protect the fleets as they approached it. By having only two decks and a lower draft, their stability to carry more and heavier guns was improved. In contrast, the galleons of the *Carrera* were intended to carry great amounts of merchandise. Three decks and a deeper draft allowed them to do so.[23]

The capacity of the *Carerra* galleons was limited, however, when compared with the Portuguese India *naus*, the largest being of about 600 tons. The distorting factor was the Guadalquivir River, which connected Seville with the port of San Lúcar de Barrameda. The Guadalquivir River had a limited capacity to receive vessels of great tonnage. As mentioned in the previous chapter, during the early 16th century, it was not inconvenient because not many vessels exceeded a 200-ton burden. By the late 16th century, however, the tonnage of the *Carrera* ships rapidly increased, reaching up to 700 tons, making it impossible to sail from Seville. Now anchoring on the bay, in front of San Lúcar and Cádiz, the *Carrera* galleons grew in size to up to 1000 tons during the following 50 years.

Measurements

Measurements used in Spanish shipbuilding were based on the *vara castellana* (0.8359 m). The *vara* could be divided into *palmos*, *dedos*, *pies de Burgos*, *pulgadas, líneas,* and *codo*s (Fig 3-5). A *palmo* was 1/4 of the *vara*, or 0.209 m. A *dedo* was 1/48 of the *vara*, or 0.0174 m. A *pie* was 1/3 of the *vara*, or 0.2786 m, and was divided into 12 *pulgadas*. A *pulgada* measured approximately 0.0232 m. Each *pulgada* could be then divided into 12 *líneas* of 2 mm each.[24]

The *codo* was the main measurement used for shipbuilding. There were two types of *codos*: the *codo castellano* and the *codo de ribera*. The *codo castellano* measured 2/3 of a *vara*, or 0.557 m. The *codo castellano* was also equivalent to 2 *pies* or 32 *dedos*. The *codo de ribera,* used in the Basque region, measured 2/3 of a *vara* plus 1/32 [of that 2/3 of the *vara*], or 0.575 m. The *codo de ribera* was also equivalent to 2 *pies* and 1 *dedo* or 33 *dedos*.

The ship's tonnage was calculated following official Spanish guidelines through the process known as *arqueamiento*, using *toneles* or *toneladas* as the measurement. According to historian Casado Soto, it is important to differentiate between the *tonelada*

Figure 3- 5. Division of the *vara castellana*

used for calculating tonnage and the one used by the crown to calculate compensation rates. And if using *toneles*, a differentiation between those of the Cantabrian coast and those of the Gulf of Cádiz must be made.[25] The *tonel cantábrico* was equal to a *tonel macho,* which is equivalent to 1.5183 m^3. The *tonel andaluz* corresponded to a *tonelada* for measuring cargo, which is equivalent to 1.3844 m^3.

Proportions

Spanish shipbuilding of the 16th and early 17th century seems to have been influenced by the Renaissance theory of proportions.[26] Such influence is seen in the comparison made oftentimes of a ship with the human body. Diego García de Palacio, author of *Instrucción Náutica* (1587), the first published nautical treatise containing valuable information regarding shipbuilding, describes the ship as follows:

> The ship […], is like the body: the timbers, like bones: the rigging and ropes, like nerves: the sails, like many little handkerchiefs, and tendons that exist in the hatch: like a mouth, it also has a stomach, and other places to be purged, and to be cleansed, like men have.[27]

Up to the beginning of the 17th century, Spanish shipbuilders adhered to the rule known as the *as, dos, tres* (one, two, three). The beam or *manga* functioned as the base, identified as *as*. For every *codo* of beam, two *codos* of keel or *quilla,* and three of overall length, or *eslora* were given. Following this rule, the depth in hold or *puntal* was usually half the beam, and the flat of the floor of the master frame was one third of the beam. This rule of proportions was used in Spain during the 16th century, and also in Italy and other European nations.[28]

Treatises

The art of navigation had undergone great changes by the end of the 15th century. The Portuguese had departed from coastal navigation and established what was to be known as "astronomical navigation". Encouraged by the interests of European states, which envisioned trans-oceanic trade as the means to their own magnificence, and filled by the Renaissance spirit of search for knowledge, navigators pursued the perfection of navigation. Their studies were reflected by means of treatises.

During the beginning of the 16th century, the first nautical treatises make their appearance in Spain. These treatises contained information on astronomy, cartography, cosmography, meteorology, and piloting.[29]

The following is a list of Spanish nautical treatises written during the 16th century:

- *Suma de geografía* by Martín Fernández Enciso – 1519
- *Quatri partitu en cosmographia practica i por otro nombre llamado espejo de navegantes* by Alonso de Chaves – 1520-1538
- *Tratado del esphera y del arte de navegar* by Francisco Falero – 1535
- *Arte de navegar* by Pedro Medina – 1545
- *Repertorio de los tiempos* by Jerónimo Chaves – 1548
- *Breve compendio de la sphera* by Martín Cortés – 1551
- *Regimiento de navegación* by Pedro Medina – 1563
- *Itinerario de navegación de los mares y tierras occidentales* by Juan de Escalante de Mendoza – 1575

- *Compendio del arte de navegar* by Rodrigo Zamorano – 1581
- *Instrucción náutica* by Diego García de Palacio – 1587
- *Luz de los navegantes* by Baltasar Vellerino de Villalobos – 1592
- *Milicia y descripción de las Indias* by Bernardo Vargas Machuca – 1599

Realizing that ships were the principal instrument in navigation, the treatises soon began to include basic information on ship construction. Of all the treatises written during the first half of the 16th century, it is the one known as the *Espejo de navegantes* that contains the first section with information on naval construction. The treatise was written by Alonso de Chaves somewhere between the years 1520 and 1538. Chaves divided his text into four books that were then subdivided into chapters and treatises. Along with information on navigation to the Indies, the author included in Chapter 3 of the third book a dictionary of shipbuilding and nautical terms.

By the last quarter of the 16th century the nautical treatises began to include relevant information on the proportions and measurements of the vessels. The two best-known examples produced in Spain during this period are the *Itinerario de navegación de las tierras y mares occidentales* written by Juan de Escalante de Mendoza in 1575 and the *Instrucción náutica para el buen uso, y regimiento de las Naos, su traza y gobierno conforme a la altura de México* written by Diego García de Palacio in 1587. In the words of historian Carla Rahn Phillips,

> García and his counterparts elsewhere were much concerned with the ideal dimensions and proportions for ocean going ships, blending theory with practical experience of the sea and moving ship design a bit further down the long road that would make shipbuilding more a science than an art.[30]

In neighboring Portugal, Father Fernando Oliveira wrote two important treatises on shipbuilding – *Ars Nautica*, in Latin, c. 1570, and *Livro da fábrica das naus*, in Portuguese, c. 1580 – but it is dubious if these texts influenced Portuguese or Spanish shipwrights, as they seem to translate or report of a shipbuilding tradition rather than propose a new one.

It was not until the beginning of the 17th century that a treatise fully dedicated to shipbuilding was published, in the form of Tomé Cano's *Arte para fabricar, aparejar naos de guerra y mercantes.* Cano's treatise was written in 1608 and published in 1611. This treatise was followed by the manuscripts of João Baptista Lavanha's *Livro primeiro de architectura naval* (in Portuguese, but relating to the ships of the united kingdoms of Portugal and Spain) and by the *Diálogo entre un viscaíno y un montañés sobre la fábrica de navíos*, attributed to Pedro López de Soto. Lavanha's treatise has been dated between 1608 and 1615. Though technically published under the Spanish crown, since Portugal was ruled by the Hapsburg kings from 1580 – 1640, Lavanha's information on ship design will not be included in this chapter because the treatise deals only with a four decked *nau* for the Portuguese India trade.[31] The *Diálogo* was written around 1632. None of these were published until the 19th and 20th centuries.

The study of these nautical and shipbuilding treatises provides great information on the evolution of Spanish ship design. Still, two things should be taken into consideration when studying the treatises in regards to their information on shipbuilding. The first is that Spanish treatises were not written by experienced shipbuilders, but rather by experienced navigators. The second is that their descriptions of the proportions and measurements represented an “ideal” ship design, which might have not been practiced.

Itinerario de navegación de las tierras y mares occidentales

Captain Juan de Escalante de Mendoza was born around 1530 in Valle de Riva de Deva in Oviedo. At a young age he was sent to study to Seville with his uncle, Captain Álvaro de Colombres. It was under the tutelage of his uncle that Escalante de Mendoza first came in contact with the art of navigation to the Indies. By the age of 18, he became captain of his own ships and, having the permission of the *Casa de Contratación*, he sailed for the Honduras fleet.[32] Escalante died in 1596 in Nombre de Dios.

Escalante concluded his treatise, *Itinerario de navegación de las tierras y mares occidentales*, in 1575. Although the *Itinerario* contained valuable information for the pilots and captains of the Indies fleet, the book never received its long-awaited permission to be published. Like many other texts of the time, Esacalante’s *Itinerario* was perceived by the Spanish crown as containing too much information that could be used by enemy states and pirates. The treatise was summarized and transcribed by historian Cesario Fernández Duro in 1880 as part of volume five of his *Disquisiciones náuticas*.[33] In 1985, the complete treatise, based on the 1791 transcription by Martín Fernández Navarrete, was published by the Naval Museum of Madrid with an introduction by Roberto Barreiro-Meiro.[34]

The treatise was written in the form of a dialogue. Escalante explained his choice for this style as follows:

> Being the way of the great Greek and Latin philosophers, who used this method for its more comfortable disposition when declaring the questions and articles that are conferred and pretended to be known in the subjects that are dealt with, and for the easier and less irritating intelligence that is to be found on the written topics…[35]

This same style was used in later treatises.

In the case of the *Itinerario,* the dialogue took place throughout the voyage to the Indies and the return voyage to Spain, and it was held by Tristán, a man inclined towards the art of navigation, and an experienced pilot, who answered Tristán's questions. The treatise is further divided into three books.

The dialogue enclosed in the first book takes place while the interlocutors navigate down the Guadalquivir River, from the city of Seville to the port of San Lúcar de Barrameda. In this dialogue, the pilot advises Tristán of the dangerous shallows found in this river and the proper way to avoid them. The pilot then continues the dialogue by explaining the basic proportions needed to obtain a well-built *nao*. Along with this information, he includes data on the tonnage of the *naos*, their rigging, and the artillery carried, among other things. One last topic mentioned in this book is the composition of the crew and their distinct chores when aboard the ship.

The second book of the treatise takes place as Tristán and the pilot leave the port of San Lúcar and continue their voyage to the ports of the occidental lands. This book contains information related to the calculation of the latitude, including the definitions of astronomical as well as cartographic and cosmographic terms used in navigation.

The third and final book occurs as the friends leave the ports of the New World and start their return voyage to the Guadalquivir. The dialogue held in this book contains information on storms, the use of the different compasses, the phases of the moon, the tides and shipwrecks, including information on the fires aboard ship that caused many of these shipwrecks.

Escalante de Mendoza on Shipbuilding

Juan de Escalante de Mendoza considered five elements as the basis to obtain a well-proportioned *nao*: the keel (*quilla*), beam (*manga*), depth in hold (*puntal*), entries and runs (*delgados y rasel*), and overall length, or *eslora*, which in most cases was measured along the first (lower) deck (Fig. 3-6).[36] Entries and runs were the concave parts of the forward and after portions of the lower hull, where the ship's width is sharply reduced for obvious hydrodynamic reasons.

The keel was the first structure laid at the shipyard. Escalante warned that it was always better to have a keel that is longer than the one needed rather than a shorter keel, He deemed that a disproportionate keel on the shorter side would produce a harder-to-man vessel. In respects to the perfect proportion of the keel to the beam of the vessel, Escalante recommended that for every 2 ¼ *codos* of beam (1.3 m), the vessel should have 5 *codos* of straight keel (2.9 m). The resulting beam to keel ratio is 1: 2.2.

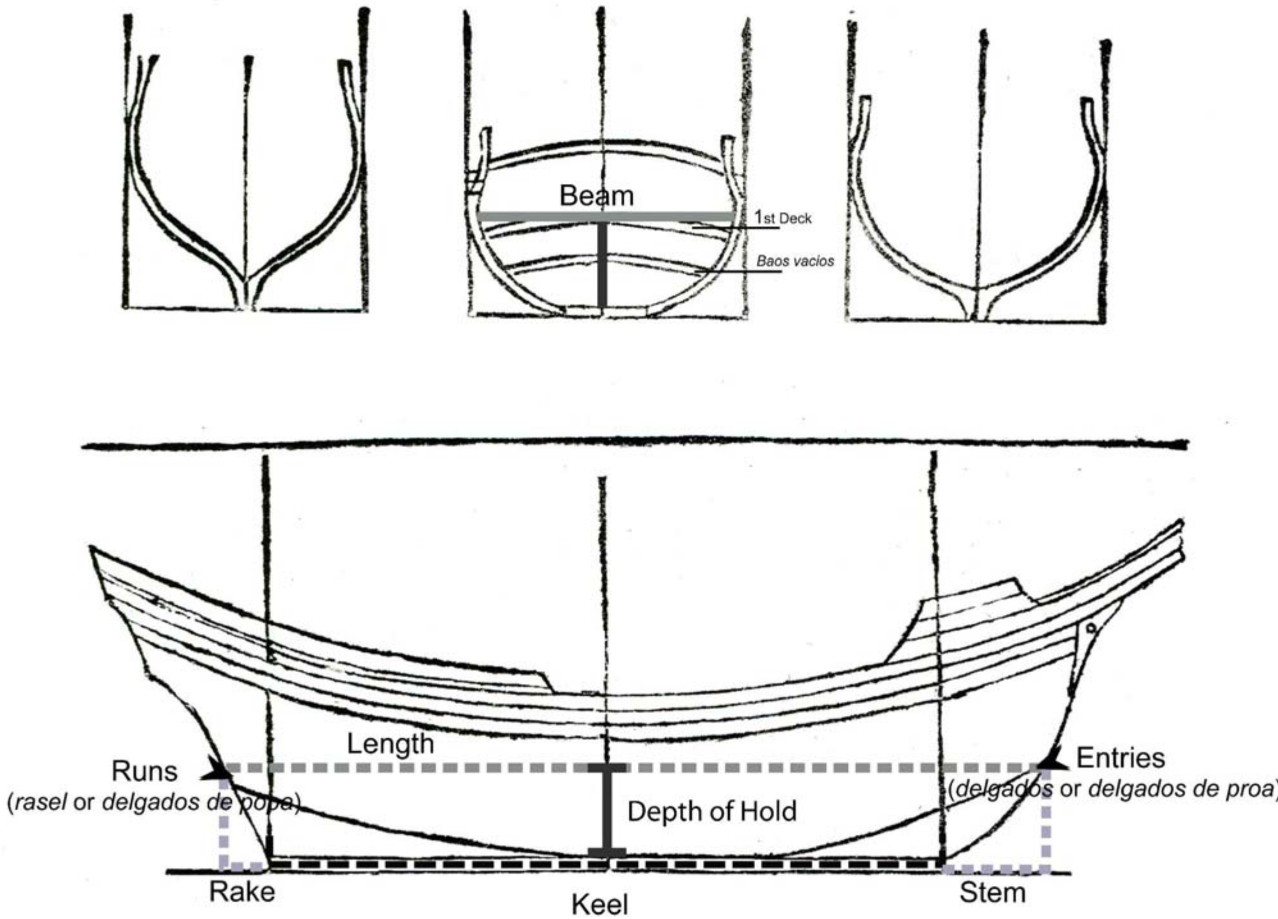

Figure 3- 6. Definition of the five main elements provided by Escalante de Mendoza illustrated on the war nao depicted in García de Palacio's treatise.

The second element he discussed was the beam. Escalante defined the beam as the widest section of the vessel, measured from starboard to port in the inner hull at the level of the first deck (Fig. 3-6). Usually, the maximum beam was located at the master frame. He also warned that the beam had to have the beam/keel proportions mentioned above. Failing to follow the proportions, Escalante said, would produce either a wider beam, which would make the vessel bad for sailing abeam, or a narrower beam, making the vessel dangerous as it would not have enough flank to support the sail.

The depth in hold was defined as the hollow area of the hull measured from top to bottom, starting at the first deck near the main mast and down to the floor of the master frame at the level of the keel (Fig. 3-6). Escalante mentioned the importance of the right proportions between the beam, the keel, and the depth in hold, but he did not provide a measurement in *codos* for this relationship. When following the *as, dos, tres* proportion rule, which he seems to follow more or less closely, the depth in hold must have been about half of the beam. More important to him was the relationship between the depth in hold and the runs. For every 5 *codos* of depth in hold (2.9 m), the vessel should have 2 ½ *codos* in the runs (1.4 m), resulting in a depth in hold/runs ratio of 1: 2.

The final elements Escalante explained were the overall length, the spring of the stem, and the rake of the sternpost. The overall length was measured at the level of the first deck from the sternpost to the stem post and the cutwater (Fig. 3-6). To obtain the length in the right proportions to the beam and the keel, Escalante stated that for every 5 *codos* of straight keel (2.9 m), 2 *codos* (1.15 m) should be given to the sum of the rake and spring of the posts, or 7 *codos* in overall length (4 m). The division on how much is to be given to the spring of the stem post and the rake of the sternpost is not provided. The resulting ratios are the following: beam / keel ratio 1: 2.2; keel to overall length ratio 1: 1.4; beam to overall length ratio 1: 3.2; and keel to posts' length ratio 1: 2.5.

On the subject of the calculation of the tonnage of the vessels, Escalante de Mendoza designated the *naos* of 500 *toneladas* as the best. He also clarified the meaning of a *tonelada* and its differences with the *tonel* used in Biscay. The *tonelada* measured 2 barrels of wine or water of the ones built in Seville, which had 27 ½ *arrobas* (436 liters). Ten of such *tonaledas* amounted to 12 of the *toneles* of Biscay.

Instrucción náutica para el buen uso, y regimiento de las naos, su traza y gobierno conforme a la altura de México

Diego García de Palacio was born near the city of Santander in the Basque country in 1524. After obtaining a law degree from the University of Salamanca, García de Palacio held several bureaucratic positions in the Spanish colonies. In 1572, he was named attorney in the *Audiencia* of Guatemala, and a year later he was named judge of the same *Audiencia*. Ten years later, after he served as mayor of Mexico City and president of the Pontífica Universidad de México, García de Palacio was appointed high court judge of the *Audiencia* of Mexico City. In 1589 he was suspended from his judge's post for nine years following corruption charges. García de Palacio died three years before he could regain the post.[37]

His treatise on navigation, *Instrucción náutica para el buen uso, y regimiento de las naos, su traza y gobierno conforme a la altura de México,* which contains general information on navigation and shipbuilding, was published in 1587 in Mexico City. This was the first treatise to be published in the New World and Europe on the subject of navigation and naval construction. A facsimile of the treatise was published in 1944 with an introduction by Captain Julio F. Guillén y Tato.[38] The treatise was also translated into English by J. Bankston in 1986.[39]

Written in the same style as the *Itinerario*, Diego García de Palacio presents the information by means of dialogues. Such conversations are held between a *Montañés* and a *Vizcaíno* (*Montañés* is someone from the province of Santander and a *Vizcaíno* is someone from the province of Biscay, both in the Basque country). The latter character is in charge of answering the many questions of the *Montañés*. The treatise is divided into four different books. Each of the books is then subdivided into chapters.[40]

The first book has nine chapters and a preface, in which García de Palacio discusses the history behind the art of navigation. The book focuses on information of the 'physical globe' and the understanding of the heavens. It also contains information on the tables of the sun's declination and explains the reasoning behind the leap year and the use of the mariner's compass. From chapter 3 to chapter 6, García de Palacio mentions some of the different instruments used in navigation. He talks about the use of the quadrant to read the position of the sun, the astrolabe and the cross-staff. Some of the other topics contained in the first book include the ways of calculating the time at nighttime with the North Star, and the navigation in Southern Hemisphere with the Southern Cross.

The second book of the *Instrucción náutica* is also divided into chapters. The book focuses on the use of the golden number. In addition, the author discusses the 'epact', the conjunction of the moon with the sun, the phases of the moon, and the rules for calculating the tides.

The third book is only divided into three chapters. The first of these chapters includes topics related to astrology, acknowledging the portents by the sun, the moon, the stars, and of the air and water. The second chapter gives information on sea-charts and their construction. Finally, the last chapter provides tables of the phases of the moon based on the latitude of Mexico City.

The fourth and final book included in the *Instrucción náutica* is divided into 33 short chapters. It is in this book that García de Palacio describes the ideal measurements for the *naos* of the *Carrera de Indias*. To exemplify such measurements, the author describes in detail, accompanied by sketches, the measurements of a 400-ton *nao* and of a 150-ton *nao*. In subsequent chapters, the rigging of these *naos* is discussed. And just like Escalante de Mendoza, García de Palacio talks about the crew and officers on board including their responsibilities.

The last chapter of the book is dedicated to warships and to naval offensive and defensive tactics. As a conclusion to the chapter and to the *Instrucción náutica,* a glossary that includes the vocabulary used by the crew is included.

García de Palacio on Shipbuilding

As mentioned above, García de Palacio describes the ideal proportions for a *Carrera de Indias* ship using a 400-ton *nao* as an example. The measurements he provides at first, book 4 - chapter 1, are for a merchant vessel. Illustrations of the 400-ton *nao*'s sheer plan and of the master and tail-frames accompany the information (Fig. 3-7a). Later on in the treatise, book 4 of chapter 33, García mentions the difference of measurements when building a warship of the same tonnage. In addition, the treatise includes illustrations of the sheer plan, breadth plan, and the master and tail-frames of a 150-ton *nao*, which the author uses in order to further clarify the necessary proportions of the ideal ship design (Fig. 3-7b).

García provided the following measurements for the 400-ton or 16 *codos* of beam merchant *nao*:

The keel was 34 *codos* (19.6 m) in length, or almost twice the beam, and was measured from the sternpost to the stem post. The resulting beam to keel ratio is 1: 2.3.

The longitudinal measurements were provided by the author as simple proportions of the keel length. The rake of the sternpost was 1/6 of the keel, or 5-2/3 *codos* (3.3 m). The spring of the stem post was double that of the sternpost, being 2/6 of the keel or 11 ⅓ *codos* (6.5 m). Adding the spring of the posts to the straight section of the keel provided the overall length of 51 ⅓ *codos*, measured from stem post to sternpost. The overall length was 1 ½ times the keel, and the beam to length ratio is 1: 3.2.

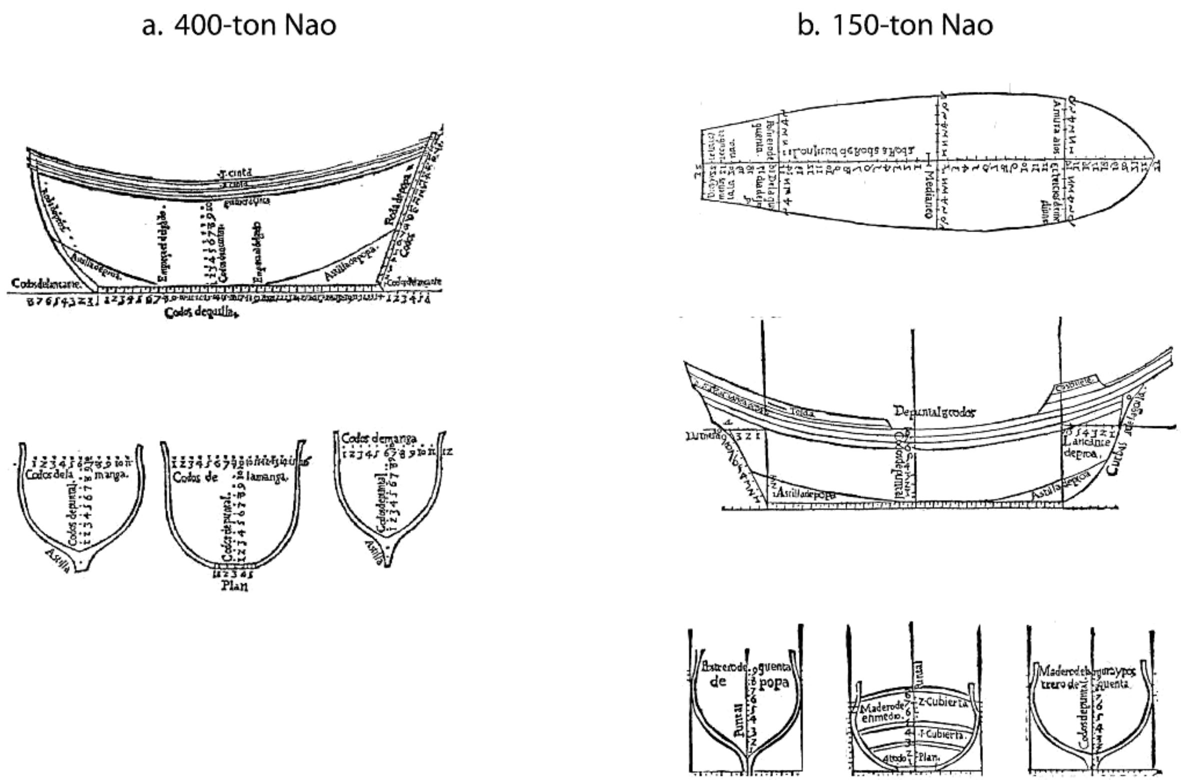

Figure 3- 7. Illustrations included in García's *Instrucción náutica*. a) 400 ton-nao b) 150-ton war nao. (After Casado Soto 1998, 125 and 137)

As for the runs, or end portions of the hull before and abaft of the central frames, the *delgados del rasel* started at the 6th frame aft of the master frame and ended at the sternpost, at a height of 6-2/3 *codos* (3.8 m) or 1/5 of the keel. The *delgados de la proa* started at the 9th frame forward of the master frame and ended at the stem post. No measurement was provided to indicate where on the stem post they should end.

García also gave the measurement of the depth in hold as proportional to the keel. The measurement provided for it was 11 ⅓ *codos* (6.5 m), or 1/3 of the keel. Based on this measurement, the resulting beam to depth in hold ratio is 1: 0.72. While the keel to beam ratio and the beam to overall length ratio closely follow the *as, dos, tres* formula, the beam to depth of hold ratio seems to be much higher than the 1: 0.5 ratio established by the rule. Rather than being a difference in design, in which García's *nao* would seem to "support the general assumption that the merchant ships in the 16th century were quite deep in the hold", the outcome of a higher ratio is obtained due to a variation in the definition of depth in hold provided by the author.[41]

García de Palacio divided the 11 ⅓ *codos* of depth in hold the following way: The first section was measured from the keel up to 4 ½ *codos* or 3 barrels (2.6 m). At the end of the section the *baos vacíos,* literally "empty beams" – designating an un-planked orlop deck – were laid. The second section was measured from the *baos vacíos* and up to the first deck. This section had 3 *codos* or 2 barrels in height (1.7 m). The third section, from the first deck to the upper deck or *puente,* was 3 *codos* high (1.7 m), totaling 10 ½ *codos* (6 m). The addition of the thickness of the beams provided the remaining *codo* to obtain the final measurement of 11 ½ *codos* of depth in hold (Fig. 3-8a). As a final

specification, García explained that if the ship carried a grating covering the main deck (*jareta*), 3 *codos* had to be added to the final measurement of the depth in hold.
As may be seen from the division provided, García defined the depth in hold from the keel to the upper weather deck. In contrast, Escalante de Mendoza measured the depth in hold from the keel up to the first deck (Fig. 3-8b). The latter definition was favored in Spanish usage. If Escalante's definition is applied to García's measurements, the depth in hold is 7 ½ *codos* or 5 barrels (4.3 m). The resulting beam to depth in hold ratio is 1: 0.47, much closer to the 1: 0.5 prescribed by the *as, dos, tres* formula.

As for the floor of the master frame, the proportions given were relative to the beam. García recommended different basic measurements for the different areas where ships were expected to serve. The vessels for the coast of New Spain, between Cozumel and Pánico, due to the shallowness of its waters should have a flat of the floor measuring ½ of the beam. Such vessels, known as *barcas del trato*, had a burden of 50 tons, and a depth in hold of 1/3 the beam. On the coasts of Peru, Nicaragua, and Guatemala, and for the service at the *Mar del Sur*, the vessels, which ranged from 50 to 100 tons, should have a flat of the floor measuring ¼ of the beam and a depth in hold of ½ the beam.

One last matter discussed on the ship design section of the *Instrucción náutica* is the difference in measurements between a 400-ton merchant *nao* and that of the same tonnage intended as a warship. The warship incorporated the same measurements of the merchant ship at the beam, keel, depth in hold, overall length and the runs. The main modification was done to the sub-divisions of the depth in hold. The beams for the *baos*

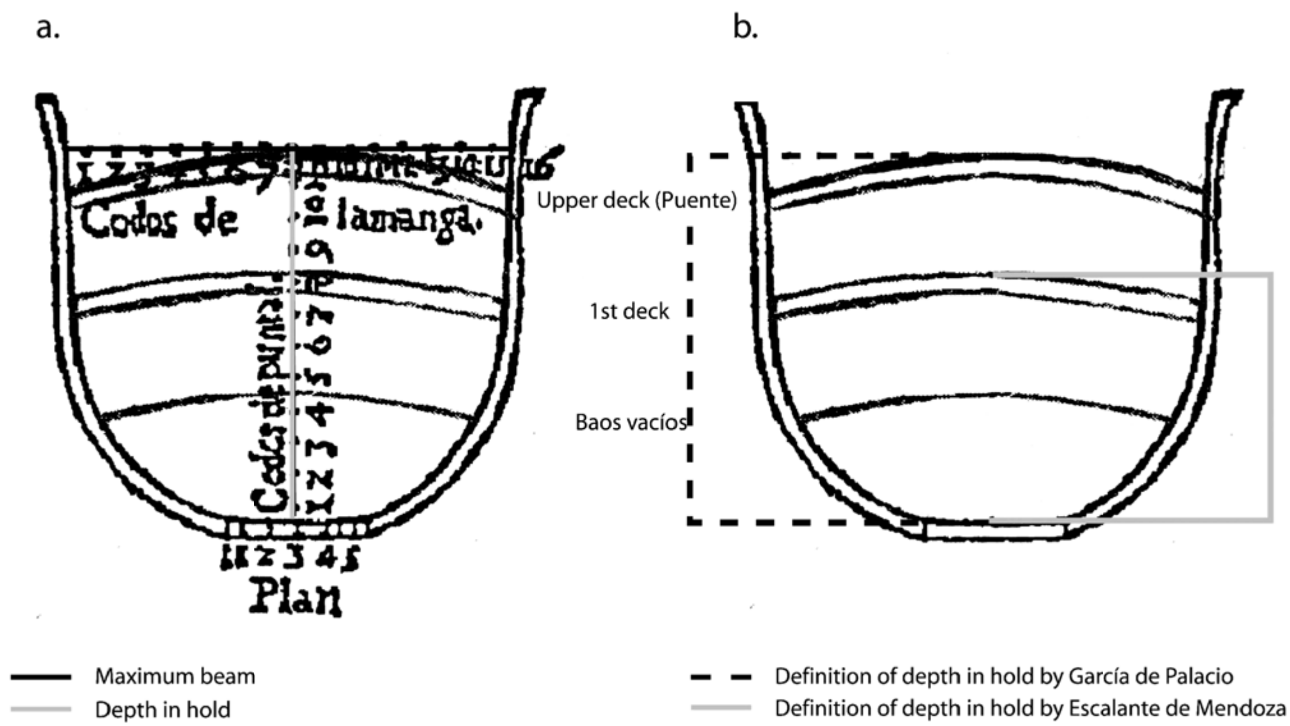

Figure 3- 8. Definitions of depth in hold according to García de Palacio and Escalante de Mendoza.
a) Divisions of the depth in hold as calculated by García de Palacio.
b) Difference of definition in depth in hold between Escalante de Mendoza and García de Palacio.

vacíos and the first deck had to be lowered by 1 *codo*, thus increasing the height of the second deck in order to provide more space for the artillery.

Arte para fabricar, aperajar naos de guerra y mercantes

Captain Tomé Cano was born in 1545 in Tenerife, in the Canary Islands. An experienced navigator, having sailed for over 54 years, and after 29 voyages to the Indies, Cano became a deputy for the *Universidad del Mar de Sevilla*, and acted as a part of the agency in charge of checking and measuring the tonnage of the vessels in the service of the *Carrera de las Indias*. Cano died in Seville in 1618.

Tomé Cano concluded his monograph, *Arte para fabricar, aperajar naos de guerra y mercantes,* in 1608, and it was published in 1611. With the permission for its publishing granted by the king, this treatise became the first treatise fully dedicated to shipbuilding to be printed in Spain. His work was considered as very important and necessary, as can be seen in the letter of approval in which Don Francisco de Corral y Toledo describes the treatise as "*El primero que, reduciendo á cuenta y medida esta fábrica, ha salido a la luz.*"[42] In 1881, the treatise was transcribed by historian Cesario Fernández Duro in volume six of his *Disquisiciones náuticas*.[43] A facsimile of the treatise was published in 1964 with a prologue by Enrique Marco Dorota.[44]

Following the example of earlier treatises, Cano wrote the treatise in the way of a dialogue. The conversation on the matter of shipbuilding begins as three friends, Leonardo, Gaspar, and Tomé (probably the author himself) sail down the Guadalquivir

River. The treatise is composed of four dialogues in which the friends discuss different matters.

In the first dialogue the friends talk about the origin and progress of the art of navigation. They also discuss the origins of the best ships and mariners, arriving to the conclusion that the title of best ships should go to those built in the Provinces of Biscay and Portugal, and that the best sailors were those of Biscayan origins.

The next dialogue consists of information on the requirements necessary for the best designing and strengthening of ships. Most of the dialogue is dedicated to the description of the measurements of a war *nao* of 12 *codos* of beam. Cano also provides information regarding the measurements of a merchant ship of the same beam. Along with the basic measurements, corresponding to the maximum beam, length of keel, depth in hold, and length overall, Cano mentions the measurement of the floor amidships, the transom, and the rudder, and provides information on the various components of the rigging, as well as anchors and cables.

The third dialogue, undergone as the friends return to the city of Pajares, is intended to explain the way in which the tonnage for merchants and warships was to be calculated.

The fourth and final dialogue includes information about the frames, the tail frames and the narrowing and rising towards the bow and the stern.

Tomé Cano on Shipbuilding

Tomé Cano begins his discourse on shipbuilding by pointing out three indispensable aspects involved in achieving a vessel of good design. The first is the measurement at the beam. Cano explains that the beam is the foundation of the design, and all other measurements of the vessel should be proportional to it.[45] The second is that shipbuilders should have knowledge of arithmetic and calculation of tonnage; so that the vessel is well-proportioned and is of the tonnage for which it was originally intended to be.[46] The third and final aspect to consider is the need to depart from the *as, dos, tres* rule. Tomé Cano defines the *as, dos, tres* rule as: "for every *codo* of beam, two of keel; for every *codo* of beam, three of length; and for three *codos* of beam, one at the floor; and the depth in hold at ¾ of the beam."[47] He attributes the problem of faulty proportions to the rule and argues that even though it considers five main measurements in Spanish shipbuilding (the beam, keel, length, floor, and depth in hold) it does not take into account the spring and rake of the posts, the runs, the transom, the rudder, the masts and yards, the sails, and the anchor of the vessel, which should also be proportional to the beam.[48]

The last statement illustrates the gradual departure from the *as, dos, tres* rule during the early 17th century in favor of a new design. Cano credits master shipbuilder Captain Juan de Veas with the reform in design, refers to it as the *nueva fábrica* and explains these new rules of proportion by using a 12 *codos* of beam (6.9 m) *nao* as an example.

The keel of the vessel had 36 *codos* in length (20.7 m). The length was obtained by applying a rule of proportion in which 3 *codos* of length of keel are given for every *codo* of beam for up to 12 *codos* of beam. Then, from every *codo* of beam starting at 13 *codos* and up to 15 *codos*, only two *codos* of length in keel should be added.[49] In that manner, the formula for calculating the length of the keel of a vessel of 12 *codos* or less of beam is:

length of keel = (beam of the vessel x 3)

and the formula for calculating the length of the keel of a vessel of 13 *codos* or more of beam is:

length of keel = (12 x 3) + [(beam of the vessel -12) x 2]

The end result is a 1: 3 beam/keel ratio for vessels of up to 12 *codos* in beam, and a lowering ratio for vessels of 13 to 20 *codos* in beam, ranging from 1: 2.9 to 1: 2.6.

The division of the hold varied depending on the function of the vessel (Fig 9a-b). If the *nao* was built to serve as a warship, the maximum breadth was set at a depth in hold of 6 *codos* (3.5 m), or half the beam; with the *puntal* or depth in hold being measured from the ceiling planking besides the keel (*soler)* to that point. The *baos vacíos* were placed at 4 ½ *codos* (2.6 m), and the first deck at 7 *codos* (4 m).[50] The gunports were 1 *codo* (0.575 m) above the deck or at 8 *codos* (4.1 m) of height above the *soler*; so that they were located 2 *codos* (1.2 m) above the waterline. The weather deck (*puente*) was then built 2 ¾ *codos* (1.6 m) above the artillery.[51] If the vessel was built to serve as a merchantman, the maximum beam was measured at 7 *codos* (4 m) above the *soler*. The *baos vacíos* were placed at 3 ½ *codos*, the first deck at 2 ½ *codos*, and the second deck also at 2 ½ *codos*. Cano prescribes the *puntal* for the merchant vessel at 8 ½ *codos*.

The author does acknowledge a difference in views between Juan de Veas and himself for the designation of the depth in hold for the merchant *nao*. While Juan de Veas instructed in his *nueva fábrica* that the depth in hold of any vessel, either merchant or warship, should be measured at a height equal to half of the beam, regardless of the position of the first (lower) deck, Cano defined the depth in hold for the merchant *nao* as the whole area where cargo may be stored (Fig. 3-9b). He continued to explain that such definition was used in Portugal and in Andalusia, and was formerly used in the Basque country.

Going back to the differences between warships and merchantmen, Cano states that the spring of the stem post should be 7 *codos* (4 m) for the warships, measured at the level of the first deck. The rake of the sternpost was set to half the spring of the stem post, or 3 ½ *codos* (2 m), also at the level of the first deck. By adding the spring and rake of the stem post and sternpost to the measurement of the straight keel, an overall length of 46 ½ *codos* (26.7 m) was obtained (Fig. 3-10).[52] Although Cano does not mention the spring of the stem and rake of the sternpost required for a merchant vessel, he does mention the overall length, which is calculated at 49 *codos* (28.2 m). Cano actually provides the measurement of the *rasel* at 5 *codos*. For the warship the *rasel* is 3 ½ *codos*, the same as the rake of the sternpost. So if it is assumed that the same applies for the merchant *nao*, the rake of the sternpost would be 5 *codos*. If the measurement is added to the straight section of the keel, which is 36 *codos*, a total of 41 *codos* will be obtained.

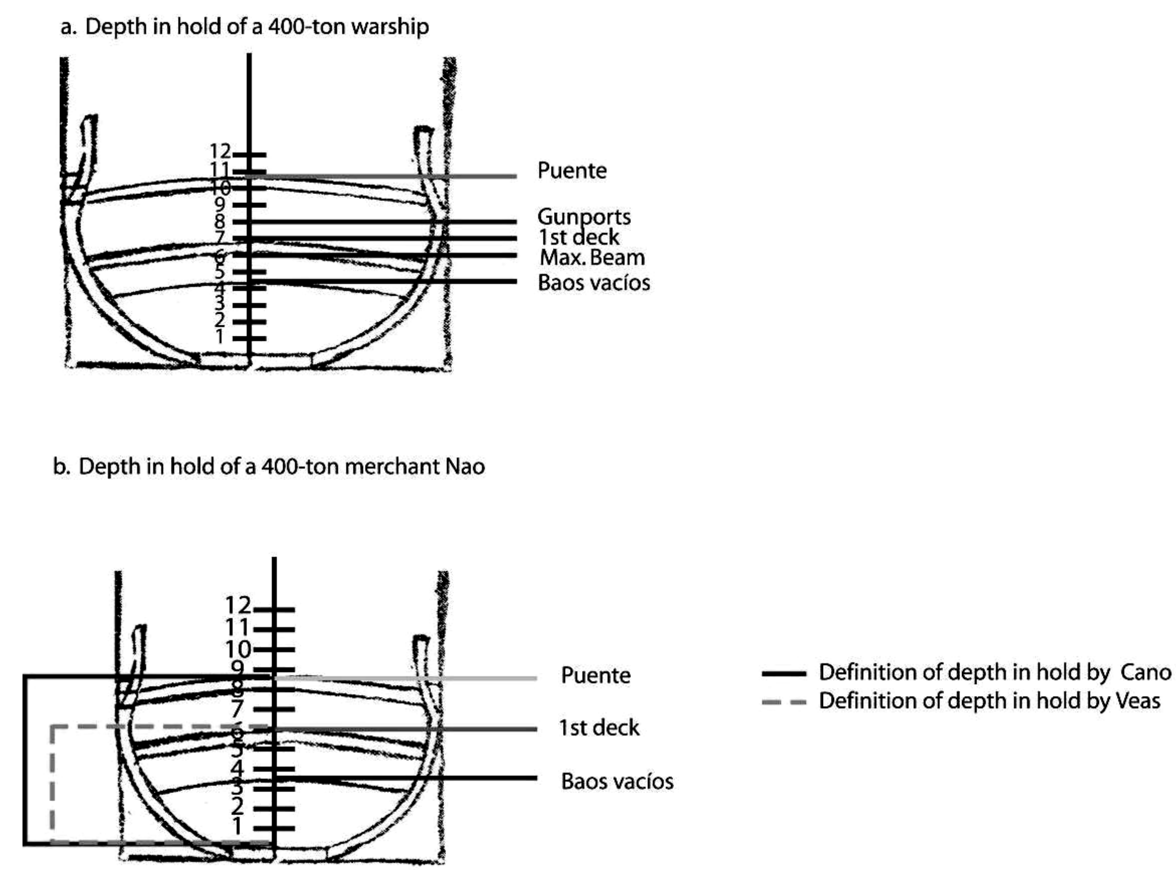

Figure 3- 9. Definitions of depth in hold according to Tomé Cano.
a) Divisions of the depth in hold for a 400-ton warship.
b)Divisions of the depth in hold for a 400-ton merchant *nao*.

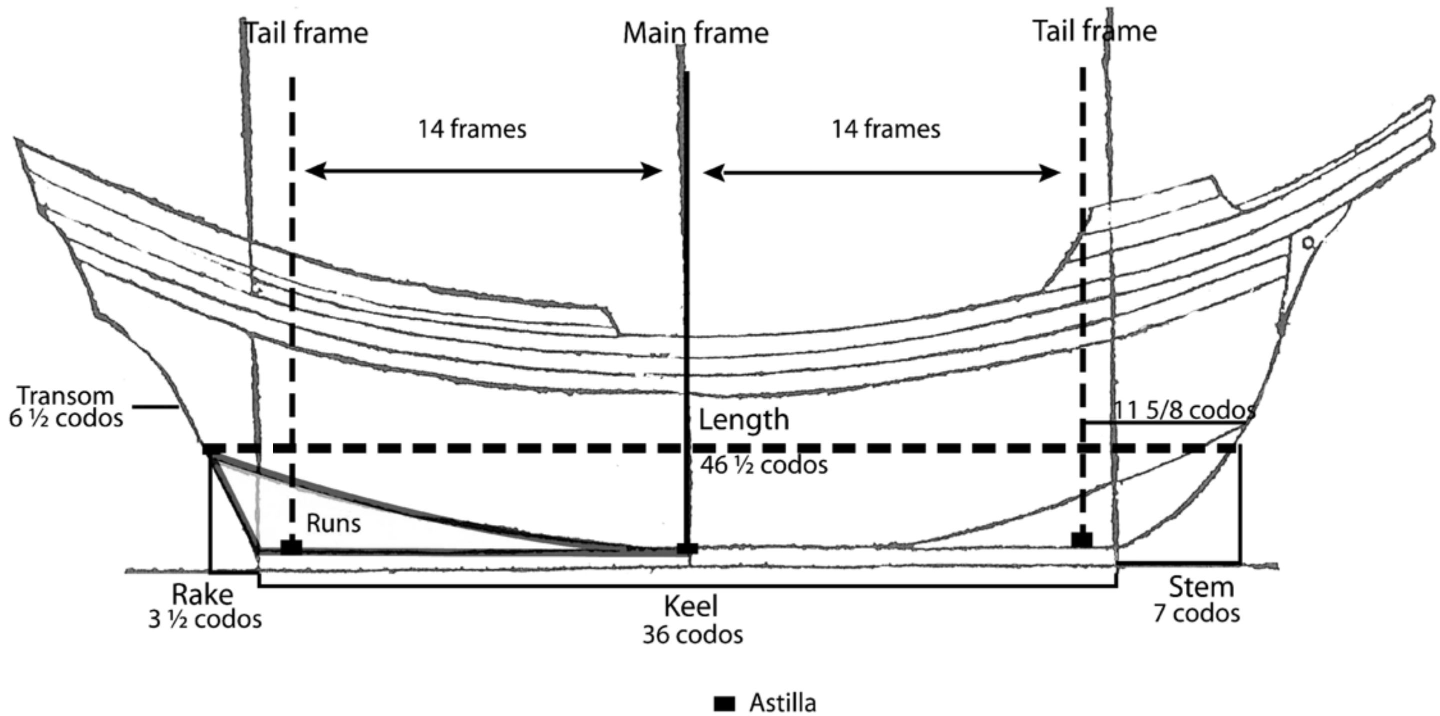

Figure 3- 10. Elements described by Tomé Cano illustrated in the war *nao* depicted in García de Palacio's treatise.

Then the spring of the stem post should be 8 *codos* in order to obtain the overall length he provides of 49 *codos*. The merchant vessel would then have 1 ½ *codos* more at the rake at the sternpost and 1 *codo* at the stem post.[53]

Other measurements provided by Cano are those of the transom and the *rasel* (Fig. 3-10). The transom of the warship had a lenght of 6 ½ *codos* (3.7 m), being calculated by taking half of the beam and adding 10 percent (of half the beam).[54] The height of the *rasel*, then, was measured at the sternpost where the flat transom begins, at a distance of half the depth in hold, or 3 ½ *codos* (2 m).[55] The height of the *rasel* for a merchant vessel was set at 5 *codos*.

This treatise is also the first Spanish written source to provide extensive information on the rising of the frames. Following Veas' method, Cano advises that a 12 *codos* of beam *nao* needs as many predesigned frames as ¾ of the length of the straight portion of the keel. That is, the *nao* with 36 *codos* of keel should have 27 frames plus the *cuaderna maestra* (master frame). But because the number of frames, including the master frame, results in an even number, an extra frame needs to be added so that there are 14 predesigned frames fore and aft of the master frame.

All the pre-designed frames, including the master frame, are given a certain amount of *astilla* (deadrise), this being a slight slope of the base of the frames in the direction of the keel. The master frame had ⅓ of a *codo* (0.2 m). The tail-frames had ¾ of a *codo* (0.4 m). The *astilla* of the frames between the tail-frames and master frame was then calculated by a geometric progression method, probably similar to the *graminho* system used in Portugal at that time. Cano explains it in this way:

> That part of the *astilla* totaling ¾ of a *codo* is to be distributed into 14 equal parts, rising each frame one point from the ⅓ of a *codo*, given to the master frame, to the ¾ of a *codo* given to the fore or aft tail-frame.[56]

Cano does not provide much information on the narrowing of the floors. The only mention of the length of the floors is at the *plan* (flat of the floor of the master frame), which should measure ½ the beam of the vessel. In the case of the 12 *codos* of beam *nao*, the *plan* should measure 6 *codos* (3.45 m).

However, Cano does mention that, according to Juan de Veas, the master frame should not be placed first on the keel, the way it had been done until that time. Instead, a piece of string should be swung from the stem post, at the 7 *codos* (4 m) point of its spring, to the rake of the sternpost, 3 ½ *codos* (2 m) forward of the end of the keel. After that, the string should be divided in fourths. One of the fourths was measured from the stem post parallel to the keel. At that distance, a plum bob should be dropped, marking the place for the fore tail frame. The remaining frames were then placed on the keel, with a distance between them measuring as much as the joint of the floor and the first futtock (Fig. 3-10).[57]

Note that the length of the cord is the same as the overall length, or 46 ½ *codos* (26.7 m). One fourth of it is 11 5/8 *codos* (6.7 m). So the fore tail-frame would be placed at 4 5/8 *codos* (2.7 m) from the start of the straight section of the keel.

One last element of great importance that is included in this treatise is the calculation of tonnage. According to the author, the calculation of the tonnage for a warship should be done by multiplying the overall length by half the beam and the depth in hold. Five percent has to be subtracted from the resulting amount in order to account for the runs, the masts, the beams, and the pumps. Once the 5 percent had been subtracted, the remaining amount should be divided by 8 in order to obtain the result in *toneladas*. If the vessel was a warship or if a merchant *nao* was to be taken into the service of the *armadas*, an extra 20 percent had to be added to the former count.[58]

If the previous rule was followed, the calculation of the tonnage of a war *nao* of 12-*codos* of beam, as calculated by Cano, was:

1. 46 x (12/2) x 7 = 1953
2. 1953 – 5 % = 1856
3. 1856 / 8 = 232 *toneladas*
4. 232 *toneladas* + 20 % = 278 5/12 *toneladas*,

and for the merchant *nao*:

1. 49 x (12/2) x 8 ½ = 2499
2. 2499 – 5% = 2374
3. 2374 / 8 = 296 ½ *toneladas*.

The formula provided by Tomé Cano may also be represented as,

$$0.95\left(\frac{E \times M \times P}{16}\right) = \textit{toneladas}$$

in which the overall length (E) is multiplied by the beam (B) and the depth in hold (P) in order to obtain the volume in *codos*^{3} of the hull, conceived as a box, and then divided by 16 to convert the result into *toneladas*. From the resulting amount, 5 percent had to be subtracted to account for the runs.

Diálogo entre un Vizcaíno y un Montañés sobre la fábrica de navíos

The treatise known as *Diálogo entre un Vizcaíno y un Montañés* provides important information on the construction of galleons during the second quarter of the 17th century. The treatise was transcribed by Martín Fernández de Navarrete during the early 1790s as part of the collection of manuscripts now housed at the Naval Museum of Madrid. Fernández stated in his transcription that the date and the author of the dialogue were unknown. Historian Fernández Duro also transcribed the text as part of volume 6 of his *Disquisiciones náuticas*.[59] Again, a date or authorship for the treatise was not provided by Fernández Duro. The treatise has been now attributed to Pedro López de Soto and dated to between 1631 and 1632 by María Isabel Vicente Maroto, who studied and transcribed the text in 1998.[60]

Pedro López de Soto was a Spanish master shipwright, overseer and accountant in Lisbon during the reign of Philip II of Spain, who was also King Philip I of Portugal. In 1595, he constructed five galleons that were to be used as part of the costal defense of the reign of Portugal, as ordered by the king.[61]

This treatise was written, like many of its predecessors, in the form of a dialogue. As the name given to the treatise explains, a *Vizcaíno* and a *Montañés,* inhabitants of the Basque Country respectively from the regions of Biscay and Santander, discuss throughout the text various matters relative to the art of shipbuilding. Included in the topics discussed are: a brief overview of the origins of shipbuilding; the attempts made by the Spanish crown to perfect ship design in the early 17th century through various ordinances that regulated the basic measurements of the ships for the Indies trade; the problems encountered on the application of the 1618 ordinances for shipbuilding; a set of new measurements and proportions that should produce better ships, including measurements for masts, yards, and sails; provisions that should be taken on board; and a description of the crew.

López de Soto explained that the main reason for which the *Diálogo* was written was the reform of the measurements provided by the 1618 ordinances for shipbuilding. In order to do this the author gave a list of the measurements for nine galleons, starting at 22 *codos* of beam and ending at 14 *codos*, and for four *pataches*, starting at 13 *codos* of beam and ending at 10 *codos*. The measurements included in his specifications for all the above vessels are: the beam, keel, overall length, depth in hold, flat of the floor, spring of the stem and rake of the sternpost, runs, transom width, and the height of both the first deck and the *puente* (weather deck) above the keel (Table 1).

In all the vessels described, the straight section of the keel should have 3 *codos* for every *codo* of beam. The overall length was calculated at approximately 3-2/3 times the beam, with the spring of the stem post always being set at half of the beam and the rake of the sternpost at 1/6 of the beam. The floor and the transom for all vessels also measured half of the beam.

The measurement that varied the most relative to the 1618 ordinances was the depth in hold, measured from the top of the keel to the main or lower deck. As the vessels decreased in beam, the depth in hold became larger in respect to the beam. The galleon of 22 *codos* of beam had a depth in hold of ½ the beam. The galleons ranging from 21 to 17 *codos* of beam had beam to depth in hold ratios of 1: 0.55. The galleons ranging from 16 to 14 *codos* of beam and the *patache* of 13 *codos* of beam had beam to depth in hold ratios of 1: 0.57. The *patache* of 12 *codos* of beam had a beam to depth in hold ratio of 1: 0.6, and the *pataches* of 11 and 10 *codos* of beam had ratios of 1: 0.67.

It is important to note that the definition of depth in hold provided by the author is neither the measurement from the top of the keel to the first deck, nor to the maximum beam level of the vessel. However, the location of the beam in relation to the depth in hold is provided for all the vessels. In all vessels, the widest section is to be set at a height equal to the value of half the beam.

From the measurements provided, it is noticeable that the author was in favor of slimmer hulls than the ones defined by the 1618 ordinances and generally all the ships that were being built at the end of the 16th century and the beginning of the 17th century. By this time, the upper works had been reduced as much as possible.

Written Sources: Contracts and Correspondence

Shipbuilders of the 16th and 17th centuries spent their lives in the dockyards learning the arts of ship construction. During this period shipbuilding methods were transmitted almost exclusively by oral communication and learned through practical experience. At the same time, the dockyard functioned as a place of negotiation. Shipbuilders would adjust prescribed formulas of ship design according to the specific requirements of the owner. Both Escalante de Mendoza and López de Soto refer to this practice in their treatises. Escalante terms this practice as the *troche moche*; criticizing its use because the vessels ended up being larger or smaller than intended. López de Soto also blamed this method, in which "everybody built the vessels their own way based only on the measurements specified by the owner", for the shortness of the keel that produced faulty vessels.[62]

The compromise of the measurements, along with information on the fortification of the vessels that were to be built, the necessary materials and their cost were written into contracts. Because in Spain the use of blueprints and scaled models was not a common practice until the 18th century, such contracts provided all guidelines and specifications for building the vessels.

The information contained in contracts, along with correspondence from the officials in charge of inspecting the vessels, therefore provides a better understanding of Spanish shipbuilding of the late 16th and early 17th century.[63]

Below are presented five examples of contracts and correspondence that provide useful information regarding shipbuilding measurements and methods for the calculation of tonnage. The documents range in date from the second half of the 16th century to the second decade of the 17th century.

Medidas y orden que suelen tener cuando se hacen las naos ca. 1560

This document, dated to around 1560, is part of a collection of documents gathered by the president of the *Casa de la Contratación* when he served as an inspector for the same institution.[64] In it the basic measurements for a *nao* of 15 *codos* of beam and for a *nao* of 15 ½ *codos* of beam are mentioned. It also describes his method for calculating the tonnage of these *nao*s, using as an example a *nao* of 10 *codos* of beam.[65]

The measurements provided for the 300 *toneles nao* are indicated as follows: 15 *codos* (8.6 m) for the beam, 32 *codos* (18.4 m) for the length of the straight portion of the keel, between 48 and 49 *codos* (28 m) for the overall length, and 7 *codos* (4 m) for the depth in hold; with the beam to keel to overall length ratio resulting in 1: 2.13: 3.2, with the depth in hold measured at a height equal to half of the beam. This ratio closely follows the *as, dos, tres* rule, and is similar to the ratios provided by Escalante de Mendoza (1: 2.2: 3.2) and by García de Palacio (1: 2.3: 3.2).

For the *nao* of 15 ½ *codos* (9 m) of beam, the measurements provided are indicated as follows: 30 *codos* (17.3 m) of keel, 50 *codos* (28.8 m) of overall length, and 12 *codos* (6.9 m) of depth in hold. The depth in hold, he explained, is measured at the *puente*; with the division of decks being of 5 *codos* (2.9 m) to the *baos vacíos*, 3.5 (2 m) *codos* above it the first deck, and from there 3.5 (2 m) *codos* to the *puente*. The main variations from this *nao* and that of 15 *codos* is that the keel is comparatively shorter, with a 1: 1.9 beam to keel ratio; and the depth in hold, if calculated to the first deck, is larger than half the beam.

In respect to the calculation of the tonnage, the method provided in this document used as an example a *nao* with 20 *codos* (11.5 m) of keel, 10 (5.8 m) of beam and 8 (4.6 m) of depth in hold. Following its rules, the keel is multiplied by the beam, and the result is then multiplied by the depth in hold, yielding a total of 1,600 *codos*^{3}.

One third is then subtracted from the previous amount in order to account for the runs. The remaining 1,067 *codos*[3] are divided by 8 to convert the result into proper *toneles*, in this case 133 1/3.

The method may be summarized by this formula, in which Q is the length of the keel (*quilla*), M is the width of the beam (*manga*), and P is the depth in hold (*puntal*):

$$\frac{\frac{2}{3}(Q \times M \times P)}{8} = toneles$$

It is important to note that the method used here to calculate tonnage by the *Presidente-Visitador* is a simple calculation of the volume of the box section of the vessel, minus the estimated volume of the runs.

Apuntamiento de Rodrigo de Vargas ca. 1570

Captain Rodrigo de Vargas acted as inspector of the *naos* from 1565 and 1575. In a letter addressed to the Duke of Medina Sidonia, Vargas explained the necessity of creating a position for an inspector based in San Lúcar, like those of Málaga and the Cantabric coast.[66] The letter contained his method for calculating the tonnage of the *naos* for the Indies fleets and included the proportions supposed necessary for well-built vessels.[67]

Vargas advocated vessels built following the *as, dos, tres* formula. The author illustrated the proportions and methods for the calculation of tonnage by using a 15 *codos* of beam *nao*. According to the *as, dos, tres* formula, the *nao* would then have 30 *codos* (17.3m) of keel, 45 to 46 *codos* (26 m) of overall length, and 7 ½ to 8 *codos* (4.5 m) of depth in hold to the first deck.

Based on those measurements, Vargas calculated the tonnage by adding the depth in hold to half of the beam, and divided the result by two. The amount obtained was then squared and multiplied by the length overall. Finally, the result was divided by 8 to convert from cubic *codos* to *toneles machos*. In this case, the vessel had a burden of 326 *toneles machos*. The method is summarized by this formula, where E is the overall length (*eslora*), P the depth in hold (*puntal*), and M the beam (*manga*).

$$\frac{E\left(\frac{P+(M/2)}{2}\right)^2}{8} = toneles$$

Furthermore, the author explained a second method for the calculation of tonnage based on the same measurements of the keel, the depth in hold, and the beam. The formula given in relation to these measurements is,

$$\left(\frac{P+(M/2)}{2}\right)^2 + (Q(P+(M/2))) = toneles$$

where P is the depth in hold (*puntal*), M the beam (*manga*), and Q the keel length (*quilla*). Note that since no measurement for the overall length is given, its multiplication is substituted by adding the multiplication of the length of the keel to the sum of the depth in hold to half the beam.

Cristóbal de Barros' Method for Calculating Tonnage - 1580

In 1580, Cristóbal de Barros had already served the crown as the chief *arqueador* in the province of Cantabria since 1563. On January 20, 1580, Cristóbal de Barros remitted a letter explaining his methods for calculating tonnage to the Marquis of Santa Cruz. That letter was immediately sent to the Duke of Medina Sidonia, who was in charge of collecting information on the different methods used for calculating tonnage throughout the kingdom.[68] For that purpose, the letter contains both the formula used by Barros and the exact places from whence measurements should be taken.

Cristóbal de Barros used the same formula as Rodrigo de Vargas. In other words, he added half the beam to the depth in hold, then squared the result and subtracted 5 percent to account for the runs. Having done this, he multiplied the result obtained by the overall length, and divided the new total by eight to convert the cubic *codos* to *toneles*. He explains that if the vessel was to serve in the *armadas*, 20 percent should be added to the total; the *toneles* are then called *toneladas*.

As for where the measurements had to be taken from, Barros states the following:

> The first thing to measure is the beam, where the vessel is widest: and at that place the height has to be taken, from the flat of the floor to the widest section; and the overall length has to be measured at this width and height, straight without lowering the measurement at the bow and the stern.[69]

Both the measurement of the depth in hold and the overall length would then be taken above the first deck. In 1590, based on Barros' method, King Philip II ordered that the measurements for calculation of tonnage had to be taken as follows:

- The beam was measured at the widest section, from port to starboard on the inner hull.
- The depth in hold was measured from the ceiling planking of the hold (*solar*) up to the level at which the beam was taken, above deck level, near the main mast or the pump.
- The overall length was measured from the stem to the sternpost, not including the width of the posts. The measurement was done on the air, straight between the tops of the posts, without lowering it to the first deck level.[70]

Galleons for the Armada de la Guarda de la Carrera de Indias -1581

In 1581 King Philip II requested eight galleons for the *Armada de la Guarda de la Carrera de Indias*. These galleons were to be designed following the measurements of the galleons built by Pero Menéndez in 1568.

On March 19, 1581, Cristóbal de Barros headed a committee in Santander dedicated to obtain the best measurements for the design of these galleons. The members of the committee included Captains Sancho de Vallezilla and Miguel de Mirravalles, who had served in the galleons built by Menéndez as master and boatswain, respectively; Captains Martín de Cubierta, Pedro de los Llanos, and Tomás de Landegorrieta; and Masters Pedro de Busturria the elder, and Pedro de Busturria, who had helped building the Menéndez' galleons.

The main concern of the committee was that the galleons built by Pero Menéndez allegedly lacked the proper proportions. It was considered that the keel was too short for a war galleon, and that its proportion to the rakes of the posts was too large. The beam and the master frame were also thought of as not being wide enough. One last concern was the tonnage of the mentoned galleons. The committee argued in favor of larger galleons that could hold more artillery and more provisions. In the final report, the committee stated the measurements used by Menéndez to design the galleons together with a list of amendments to the existing measurements for designing the galleons ordered by the king (Table 2).[71]

A few months after the committee met in Santander, a new committee meeting took place in the city of Seville. On this occasion, the committee was formed by five of the best mariners of the city: Diego Flores, Diego Maldonado, Cristóbal Monte, Pedro Sarmiento, and Diego Sotomayor. The purpose of the assembly was to consider the perfect design of the eight galleons required by the king (Table 3).[72]

After receiving the report from the committee of Seville, Cristóbal de Barros called for a second meeting in Santander, held on September 2, 1581 with the original committee members. In their final report, the measurements given by the committee of Seville were revised (Table 4).[73]

The three committee meetings aimed at obtaining the best possible measurements for the galleons. In the first meeting of the Santander committee, Barros called for larger, longer galleons. The proportions obtained from the measurements proposed were 1: 3.1: 3.6. These proportions were closer to the proposed *nueva fábrica* of Captain Juan de Veas in the early 17th century. Revising these values the committee from Seville recommended that the galleons' construction follow the *as, dos, tres* formula more closely. The proportions obtained from their measurements were 1: 2.2: 3.3. In the final committee of Santander, Barros compromised between the measurements from the committee of Seville and his own proposed measurements, while still calling for longer galleons. The proportions obtained from the final values were 1: 2.3: 3.5.

Six Galleons by Captain Juan de Veas ca. 1613

Captain Juan de Veas served as the master shipbuilder under King Philip III from 1606 until his death in 1615. As has already been mentioned, Veas was credited with the innovation of the rules of shipbuilding and was the first to advocate the departure from the *as, dos, tres* rule. His concept of the *nueva fábrica* was explained earlier in this chapter.

One of the surviving documents pertaining to his actions as master shipbuilder is a contract for six galleons and a *caravelón* to be built in the shipyard at Havana. The date of the contract is unknown. Taking into consideration that the measurements of the galleons are consistent with those provided in the 1613 ordinances for shipbuilding and that the shipbuilder died on 1615, the document can be dated to between 1613 and 1614.[74] As a first stipulation, the contract specified the measurements for the beam, length of keel, depth in hold, and overall length for the six galleons. The contract also contained information on the ‘fortification’ of the vessels, the materials that were to be used and their place of origin, and of the money allocated for the project.

According to the contract, the measurements for all six galleons were: 17 *codos* of beam (9.8 m), 46 of keel (26.5 m), 58 ¾ of length (33.8 m), and 8 ½ of depth in hold (4.9 m), measured to the first deck. The measurements were consistent with the values required by the 1613 ordinances for constructing a galleon of 539 ¼ tons.

Other measurements may be added to the information provided by the contract by looking at the ordinances.[75] Following the regulations, the first deck was placed 8 ½ *codos* (4.9 m) above the keel (the depth in hold). The *puente* was set 3 1/8 *codos* (1.8 m) above the first deck. The spring of the stem post was set at 8 ½ *codos* (4.9 m) measured at the level of the 1st deck, and the rake of the sternpost at 4 ¼ (2.5 m). The galleons would have 25 pre-designed frames including the master frame; 12 frames aft of the mainframe, and 12 frames forward. The flat of the floor of the master frame measured 8 ½ *codos* (4.9 m). The *delgados de proa* were calculated at 5 2/3 *codos* (3.3 m), and the *rasel de popa* at half that distance. The transom measured 8 ½ *codos* (4.9 m).

These measurements were consistent with Veas’ *nueva fábrica* configuration as described by Tomé Cano. The length of the keel was obtained by multiplying the first 12 *codos* of beam by 3 and the remaining 5 *codos* by 2. The depth in hold measured half the beam. The same was true for the floor of the master frame, the spring of the stem post, and the transom. The rake of the sternpost was half of the spring of the stem post. All of the above were proportion rules used in the *nueva fábrica*. The *delgados* and the *rasel* also had the 1: 2 relation used by Veas.

During the end of the 16th century and beginning of the 17th century, Spanish shipbuilding gradually departed from the *as, dos, tres* formula. The search for new measurements to obtain the 'ideal' vessel for the *Carrera de Indias* compelled the different authors to express their ideas, methods, and definitions on the subject of shipbuilding. The results may be observed throughout the written sources of the period.

In the same manner, the 'ideal' method for the calculation of tonnage was sought during this period. The final objective was the creation of a method for the calculation of tonnage that could be used throughout all the regions of Spain.

However, shipbuilding practices in Spain were still defined by individual methods that adhered to the demands of merchants. It would not be until the first decade of the 17th century that the Spanish crown took an active role in the discussion. In 1605, Philip III of Spain (Philip II of Portugal) gathered experts in the arts of navigation and shipbuilding to create standard measurements for shipbuilding and calculation of tonnage in the Iberian Peninsula. The end product was the publication of a series of laws known as the *ordenanzas para la fábrica de navíos de guerra y mercantes* of 1607, 1613, and 1618.

ENDNOTES CHAPTER III

[1] Crumlin-Pedersen 2004, 47

[2] Steffy 1994, 84

[3] Castro 2005, 34

[4] Lane 1992, 89

[5] http://brunelleschi.imss.fi.it/michaelofrhodes/manuscript.html accessed in March 24,2008.

[6] Steffy 1994, 96-99

[7] Lane 1992, 89

[8] Oertling 2001, 238

[9] Phillips 1993, 230

[10] Glete 1993, 38

[11] Fernandez Duro 1880, 5:10

[12] Casado Soto 2001, 132

[13] Ibid, 132

[14] Ibid, 132

[15] Ibid, 133

[16] Veitia Linage 1945, 650. Translated by author.

[17] Ibid, 650-2. Translated by author.

[18] The translation of the treatise by English Capt. John Stevens refers to the Balandraa as of Dutch construction, not of English construction, as mentioned by Veitia.
Veitia Linage and Stevens 1702, 272

[19] Phillips 1993, 231

[20] Serrano Mangas 1992, 12

[21] Apastegui 2001, 164

[22] Serrano Mangas 1992, 14-5

[23] Ibid, 17

[24] Rubio Serrano 1991, 94

[25] Casado Soto 1988, 70

[26] During the Renaissance, the theory of proportions, as explained by art historian Erwin Panofsky, "achieved an unheard-of prestige". The human body was seen as the perfect design. Its proportions were reduced to general arithmetical and geometrical principles, such as the geometrical progressions of the "golden section". In architecture, human proportions were associated with proportions in buildings, following the teachings of 1st century architect Vitruvius. Panofsky 1955, 91-2

[27] García de Palacio 1544, 89. Translated by the author.

[28] Cano and Dorta 1964, 62

[29] For more information on the listed nautical treatises see Vicente Maroto 2004, 477 – 513

[30] Phillips 1993, 231

[31] Lavanha, João Baptista, *Livro Primeiro de Arquitectura Naval* (c. 1608), Lisbon: Academia de Marinha, 1996.

[32] Escalante provides a short autobiography at the beginning of his treatise.

[33] Fernandez Duro 1880, 413-515

[34] Escalante de Mendoza 1985

[35] Ibid, 22

[36] Ibid, 39

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[37] Laanela 2006

[38] García de Palacio 1944

[39] García de Palacio 1986

[40] García de Palacio 1944, 5-6

[41] Phillips 1987, 294

[42] Cano and Dorta 1964, 36

[43] Fernandez Duro 1881, 36-96.

[44] Cano and Dorta 1964.

[45] Ibid, 61

[46] Ibid, 61

[46] Ibid, 62

[47] Ibid, pg 62

[48] Ibid, 62

[49] Ibid, 66-7

[50] Ibid, 69

[51] Ibid, 67

[52] Ibid, 67

[53] Ibid, 91

[54] Ibid, 68

[55] Ibid, 68

[56] Ibid, 103

[57] Ibid, 104

[58] Ibid, 90-2

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[59] Fernandez Duro 1881, 106-222.

[60] Vicente Maroto 1998

[61] Ibid, 24

[62] Escalante de Mendoza 1985, 38; Fernandez Duro 1881, 108.

[63] Vicente Maroto 2004, 511

[64] Casado Soto 1988, 80

[65] AGI, *Patronato*, leg. 260,2 , r.° 42.

[66] Casado Soto 1988, 84

[67] AGI, *Real Patronato*, leg.260, 2°, r° 35

[68] Casado Soto 1988, 85

[69] AGS, Guerra Antigua, leg. 96, n° 63. Translated by author.

[70] BNM, Sección de Manuscritos, n°c1816, fols.

[71] AGS, *Guerra Antigua*, leg 111, n° 166

[72] MNM, *Col. Navarrete*, t.22 fols. 314-5

[73] AGS, *Guerra Antigua*, leg 17, n° 98

[74] Navarrete 1971, 259-63.

CHAPTER IV

ORDENANZAS PARA LA FÁBRICA DE NAVÍOS DE GUERRA Y MERCANTES – 1607, 1613, 1618

In 1605, Admiral Diego Brochero described the problems that, in his opinion, haunted the *armadas* of Spain. These, he maintained, were the lack of respect for the crew, the lack of quality of the vessels, the lack of ropes and cloth for sails, and a similar lack of fastenings and artillery of quality. He explained that:

> The forces at sea do not consist of maintaining and building galleys and vessels if they come out wrong, in order with few people and miserable sailors, with little ropes and sails, artillery poorly placed and equipped, so that any storm can defeat them and destroy them. There is no doubt that four vessels in order are of more substance and benefit than twelve built the way they sail today, either for fighting or for navigation.[1]

The problem of leasing merchant vessels for the use in the *armadas* of the king was also exposed. On this subject Brochero explained that, in order to avoid having their vessels taken for the king's *armadas*, merchants built them heavily, with decks lowered, and with great disproportion so that they could not carry artillery or soldiers. Due to this, if a general embargo was necessary, vessels of the required quality would have been difficult to come by, making it impossible to create a large *armada* and thus risking the loss of lives, vessels, and merchandise.

To solve the problems that disturbed the Spanish naval industry, Brochero recommended the creation of an assembly composed of people of great knowledge in the navigational arts, together with some of the best shipbuilders. The purpose of such an assembly was to compose and adjust the design, measurements, and fortifications of the vessels; making sure that these new specifications ranged from a small *patache* to the largest galleon. By doing this it was intended, on the one hand, to stop the alleged trickery, and on the other hand, to consolidate all the varying opinions on the matter of proportions and fortifications. In addition, the problem with the embargoes of ships would have been solved. With the creation of such specifications, the vessels built privately and the galleons built by the king would have been the same. If it was necessary to create an *armada*, it would have only been necessary to embargo enough merchant vessels and provide the necessary men and artillery. Merchants considered the vessels built by such new rules better suited for the Indies trade.

Brochero also considered of great importance the need to establish a unified way to calculate the tonnage of the vessels and the use of a standard unit of measurement, in this case the *codo*. On this subject the admiral explained that:

> In Biscay and Andalusia tonnage is calculated one way and in Portugal it is calculated very differently, and through this counsel the methods of shipbuilding, calculation of tonnage, and the only *codo* with which measurements will be taken in all His Majesty's kingdoms, will be agreed once and for all, because with the methods for calculating tonnage used up to date some vessels get more than they are entitled to and some less.[2]

So it was that under the main advice of Admiral Brochero, eleven experts, including several of the best shipwrights and experts of navigation of Biscay (i.e. Juan de Uriarte, Martín de Zautua, Juan de Axpe, Domingo de Varienga, Martín de Sauto, Martín de Larraondo, and Juan de Veas) and of Portugal (i.e. Valentín Temudo and

Captains Martiarto and Pedro de Sancturse) assembled in Madrid to discuss and establish an optimum set of design specifications.[3]

The result was the expedition of the first ordinances for the construction of war and merchant ships (*ordenanzas para la fábrica de navíos de guerra y mercantes*) on December 21, 1607. From this point on, all ships built in Spain and Portugal were to be constructed following the measurements and fortification standards established within the ordinances.

These ordinances were not easily accepted by shipwrights and merchants, who argued that the measurements and proportions dictated by the ordinances produced deficient ships. On this matter, Juan Beltrán del Puerto and Juan Echavarri, shipwrights of the province of Guipúzcoa in Biscay, argued that because the vessels were too long and with little depth in hold in relation to the beam, they rolled over during storms, were hard to maneuver, could not carry the necessary supplies and did not have enough space for artillery between decks when used as warships. Conversely, they argued that these ships did not have enough space for merchandise when used as merchantmen.[4]

Shipwrights and merchants refused to follow the ordinances with little regard for the consequences. For instance, after having visited a shipyard at Rentería in Biscay, Colonel Domingo de Idiáquez - the appointed superintendent of the province of Guipúzcoa in charge of inspecting all constructions, calculating the tonnages, and overviewing the *plantíos* (plans) – reported on November 24, 1609 that the galleons being built by Juan de Plazanal and Baltasar de Aramendi adhered neither to the measurements nor the structure as specified by the new ordinances.[5] After the first visit the owners were fined 500 ducats each and were ordered to fix the vessels. By the second visit the problems had not been fixed. The owners were once again fined 500 ducats each and warned that if the problems were not fixed by the following visit all construction would be suspended. Still, the owners never adhered to the ordinances, arguing that the costs of following them were too high.[6] Cases like the one presented above occurred frequently after the promulgation of the ordinances.

In 1610, the year when the 1607 ordinances began to govern, a Royal decree was circulated calling for a second assembly of the experts in navigation and shipbuilding to correct the mistakes of the ordinances.

The discussions lasted for two years due to the vast diversity of opinions over the subject, especially due to the debate created by those advocating practical knowledge above theory.[7] On June 6, 1612 a new set of ordinances was sent to King Philip III for approval, and these were signed on July 1st of the same year.[8]

Copies of the new ordinances were also sent to Luis Fajardo, the Duke of Medina Sidonia, and Admiral Diego Brochero for their final approval.[9] On this subject, both the Duke of Medina Sidonia and Luis Fajardo thought that the only measurement that had to be adjusted was that of the keel. The former opined that for every *codo* of beam the keel should have 2 *codos*. The latter declared that it was only necessary to reduce the length of the keel of all vessels by 1 *codo*. On the same matter, Diego Brochero affirmed that the measurements as presented by the new ordinances were ideal and no change was to be made. Following the advice of Brochero, the new ordinances were not changed. They were finally published on July 6, 1613.

Like their predecessors, these new ordinances were a subject of controversy. Even before their publication, the representatives from the shipyards of Biscay disputed the tendency of creating vessels that were better suited as warships, insisting that interests of the merchants were sacrificed over the interests of the State. In the province of Guipúzcoa shipbuilders and merchants demanded once more that their freedom in matters of ship design and construction be reinstated. [10] In Seville an assembly was formed by Admiral Aparicio Arteaga and shipbuilders Diego Ramírez and Álvaro de Utera with the purpose of creating a report explaining all the problems that resulted from the new measurements and fortifications. The report classified the vessels as being short of beam, insecure and ultimately bad. [11]

This situation of unrest did not end until 1618 when, after yet another council was summoned, the ordinances were amended for a second time. The third and final set of measurements and fortifications was published on June 16, 1618. Although these new ordinances were not met with great enthusiasm by shipbuilders and merchants, they were accepted as the best compromise they were likely to get from the State.[12]

The method used to calculate the tonnage of the vessels included in the 1607 ordinances had been considered less than ideal. This method was regarded as faulty mainly because it was thought that the people who were included in the council were not people of science, and thus, the knowledge of mathematics and geometry had not been applied.[13] To solve this problem the Council of War had called for a second meeting in 1612. This time the assembly was composed of expert mathematicians (Luis Arias de

Loyola, Juan Cedillo Díaz, Antonio Moreno, and Don Alfonso Flores) and experts on navigation and shipbuilding (Juan de Pedroso and Juan de Veas).[14]

The main objective of that assembly was to standardize the methods used for the calculation of tonnage and the measurement of the *codo* that was to be used for this purpose across the entire reign. The result was the publication of a separate ordinance on October 19, 1613 dedicated solely to the calculation of tonnage.

This ordinance, unlike the one dedicated to the measurements and fortifications published the same year, was not overruled in 1618.

Ordenanzas para la fábrica de navíos de guerra y mercantes – 1607

The first shipbuilding ordinances were expedited in Madrid on December 21, 1607. A copy of these ordinances was filed in the archival collection at the Simancas General Archive, under the documents known as *Cartas y otros papeles tocantes a las pretensiones de los mareantes de Sevilla, causados desde el año 600, 1602 a 1640*. This copy was later transferred to the Indies General Archives in Seville. Martín Fernández de Navarrete transcribed this archive in 1792, and included the 1607 ordinances in his collection of documents and manuscripts, now housed at Madrid's Naval Museum. The complete collection was also published in 1971.[15] The ordinances are found in volume 23-I, pages 575 to 593 of this publication.

Based on the document transcribed by Fernández de Navarrete, the 1607 ordinances can be divided into four general sections. The first section corresponds to the measurements by which both merchantmen and warships were to be constructed. The second section specifies how the hull structure or *fortificaciones* were to be done. The third proposes a standard way to calculate tonnage; and the fourth and last part refers to the way in which the shipbuilders were to serve and be paid.

The measurements contained in the ordinances were to be used to:

> build galleons, and other vessels for the *Armadas del Mar Océano*, and for the Indies trade; being of the tonnage and perfection that is necessary, from the smallest to the largest, both for war and commerce.

In total the measurements for 13 vessels were provided. These vessels were classified based on their tonnage and the type as *Navíos, Galeoncetes*, and *Galeones*. The three *navíos* described range from 151 ½ to 238 ¼ *toneladas*, or 10 to 12 *codos* of beam. The two *galeoncetes* described were of 297 5/8 and 373 3/8 *toneladas*, or 13 and 14 *codos* of beam. The eight galleons (*galeones*) described range from 487 1/8 to 1351 5/8 *toneladas*, or 15 to 22 *codos* of beam.

The proposed measurements that defined the shape of the vessels were those of the depth in hold (*puntal*), the overall length (*eslora*), the keel (*quilla*), and the entries and runs (*raseles*) (Fig 4-1); the 1607 ordinances included the location of the main deck, the second deck (*puente*), and the aft and fore castles (Table 5).

The three *navíos* had only one deck. In all cases the location of the maximum beam was at the level of the depth in hold. The aft-castle (*alcázar*) was set 2 2/3 *codos* (1.5 m) above the main deck, and would extend up to the main mast. The fore-castle (*batallera*) was also set 2 2/3 *codos* (1.5 m) above the main deck.

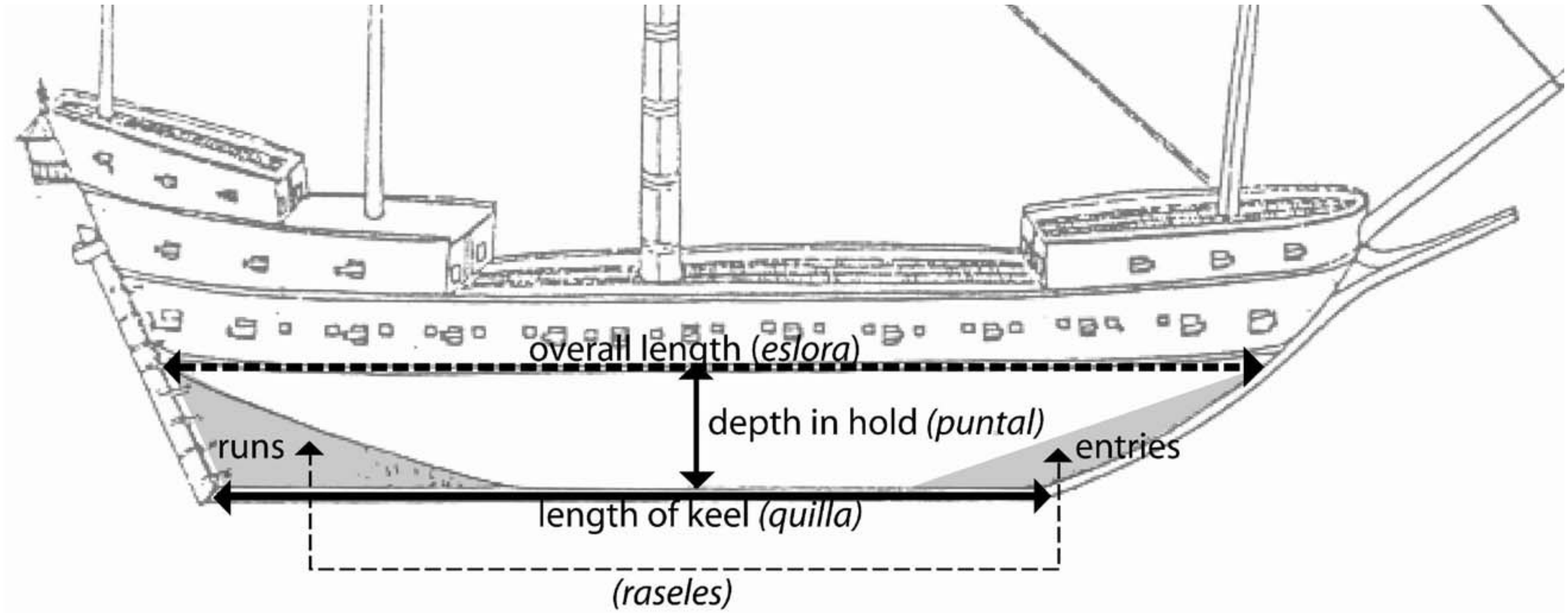

Figure 4- 1. Measurements given by the 1607 ordinances.

Like the *navíos*, the *galeoncetes* also had only one deck constructed at the height at which the depth in hold was measured. The overall length was measured on it. The fore and aft castles of the *galeoncete* of 13 *codos* of beam were set at the same distance from the main deck as the one mentioned for the *navíos*, which is 2-2/3 *codos* (1.5 m). For the *galeoncete* of 14 *codos* of beam, the fore and aft castles were set at a new height, 3 *codos* (1.7 m) above the main deck.

Galleons had two decks. The main deck, like that of the previous vessels, was set at the height at which the depth in hold was measured. The second deck or *puente* was set at a height of 3 *codos* (1.7 m) above the main deck. The deck beams of smaller dimensions (*latas*) than the main beams (*baos*) of the second deck, were fixed at that height. Then the fore and aft castles rose 3 *codos* (1.7 m) above the *puente*.

Of all the measurements provided by the ordinances only the measurement of the depth in hold maintained the same relation with the measurement of the beam. For all the vessels considered, the depth in hold was half the beam plus half a *codo*.

As for the relationship between the beam and the length of the keel, the *navío* of 10 *codos* of beam had a beam to keel ratio of 1: 2.9. This ratio increased by 0.1, or 1: 3 for the *navío* of 11 *codos* of beam, and stayed the same for the *navío* of 12 *codos* of beam. Starting from the *galeoncete* of 13 *codos* of beam and up to the galleon of 18 *codos* of beam, the ratio beam to keel decreased about 0.1 for every *codo* of beam that was increased. That is, the *galeoncete* of 13 *codos* of beam had a beam to keel ratio of 1: 2.9; the *galeoncete* of 14 *codos* of beam had a ratio of 1: 2.8; and so on, reaching a beam to keel ratio of 1: 2.4 for the galleon of 18 *codos* of beam. The remaining galleons maintain approximately the same ratio of 1: 2.4.

The overall length was measured from the stem post to the sternpost at the level of the main deck. To obtain its length, the rake of the stem and sternposts was added to the length of the keel (Fig 4-1). However, the 1607 ordinances did not provide the spring and rake to be given to the stem and sternposts, though usually half of the spring of the stem post was given to the rake of the sternpost.

The entries and runs were defined as the end portions of the hull, before and after the tail frames. The measurement provided by the ordinances was the combined measurement for the *delgados de proa* (entries or fore-runs) and the *rasel de popa* (aft-runs) (Fig 4-1).

Once the design measurements were given, the ordinances specified the manner in which the hulls were to be built and reinforced. After the keel (*quilla*), the stem post (*branque*) and the sternpost (*codaste*) were laid, the shoring (*escorado*) was done in order to support the hull under construction. Once this step was completed, the false keel was fastened to the keel. The keel was then furnished with the floors and the first futtocks of the pre-designed frames (*cuadernas de cuenta*), and the main mast step (*carlinga mayor*) with its necessary buttresses (*bularcamas*) was placed. Then, the keelson was fastened to the keel with spikes driven from the keelson sides. The stem post was fastened to the inner stemson (*contrabranque*), before placing the cutwater (*tajamar*) (Fig 4-2a). The inner sternpost (*contracodaste*) was then fitted to the stern

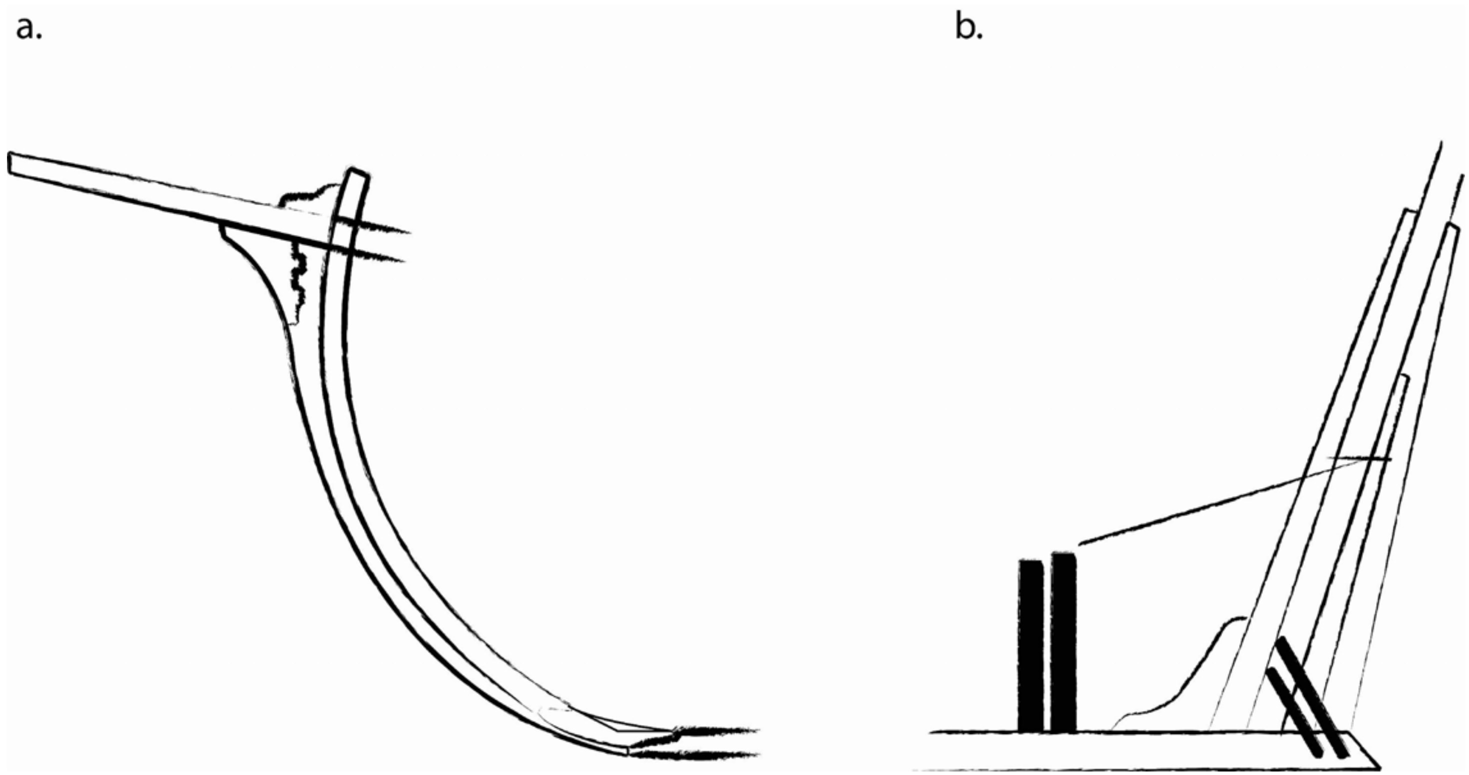

Figure 4- 2. Structures of the bow and stern as specified by the 1607 ordinances.
a) *Fortificaciones de proa*: sternpost, sternson, cutwater.
b) *Fortificaciones de popa*: sternpost, inner sternson, outer sternson, stern knee, transoms,Y-frames.

knee and the transoms (*puercas*), and was fastened to the sternpost before the Y-frames (*picas*) were closed. The sternpost was reinforced with an outer post (Fig 4-2b).

As for the deck structure, the location was given for:

1. the main beams (*baos*), shelf clamps (*durmientes*), waterways (*trancaniles*), knees (*corbatones*);
2. carlings (*cuerdas or esloras*), and wales (*cintas*);
3. deck beams of smaller dimension than the *baos* (*latas*).

The orlop deck, which consisted of a series of un-planked beams (*baos vacíos*), was placed at the union of the scarves of the first futtocks and the bilge stringers. The distance between these beams was equal to the height of one *pipa* (2 ½ *codos* or 1.4m). A rider, fastened to the main mast step, was placed underneath each *bao vacío*. The main deck's lower clamps (*contradurmientes*) had to be as wide and strong as possible, and had to be fastened to the deck's knees and the wales. Above the lower clamps were the clamps *(durmientes)*. The *latas* along the whole main deck had to be at the level of the beams, and the distance from *lata* to *lata* should be of 3 *codos* (1.7 m). The *latas* were joined to the clamps by the method known as the *cola de milano* (dove-tailed) (Fig 4-3), and the heads of the *latas* were bolted to the clamps. Hanging knees were used to support every fourth *lata*. The waterways had to be of the best possible quality wood and wide enough to be able to be bolted through the head of the *lata* and the clamp. Carlings (*cuerdas*) were used to lend support to the *baos* and *latas*. The second deck was built the same way.

The first three wales had to be double, as used by the Portuguese, and the remaining single. The wales were fastened to the clamps of the main deck, the *puente*, and the fore- and aft-castles, without protruding more than 2 *dedos* (0.04 m) from the hull. Their width had to be of at least 1/3 of a *codo* (0.2 m) (Fig 4-4).

This section also specified the thickness of the planking and the dimensions of the gunports for all the vessels. The thickness of the planking up to the first wale was 1/5 of a *codo* (0.12 m), and above that first wale of 1/7 or 1/8 of a *codo* (0.08 or 0.07m) for vessels larger than 300 *toneladas*. The thickness of the planking at the *puente* had to be of 1/6 of a *codo* (0.09m), and if possible made of pine from Flanders. Above the second deck the plank should be as thin as possible. As for the gunports, the measurement given was of 1 ¼ *codos* (0.7 m) per side.

The 1607 ordinances did not provide much information about the frames of the vessels. Only the measurement of the floor timber of the master frame (*plan*) was regulated for all vessels, and should be of half the beam; so that the vessels would draw less water. As for the pre-designed frames, it was only explained that the number of frames depended on the runs and the length of the vessel.

As mentioned above, the new regulations for the measurements and hull structure were deemed effective by the beginning of the year 1610. From this year on, the vessels of the merchants that followed the new regulations had preference in obtaining permits for navigation and for loading their merchandise for traffic in the *Carrera de Indias*. The preference was given on the assumption that these new vessels were safer and better designed.[16]

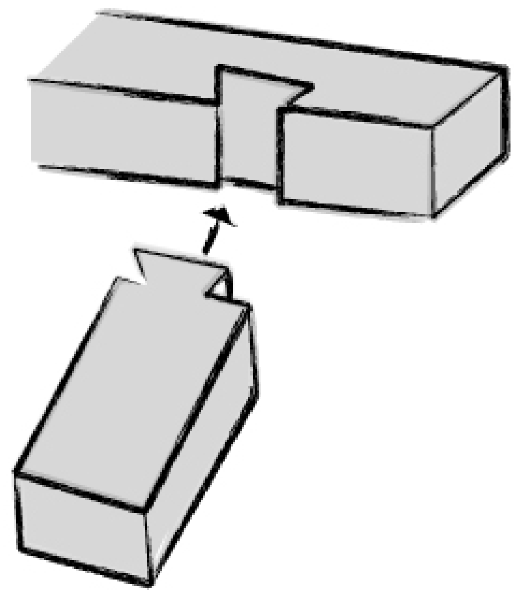

Figure 4- 3. Dove-tail (*cola de milano*).

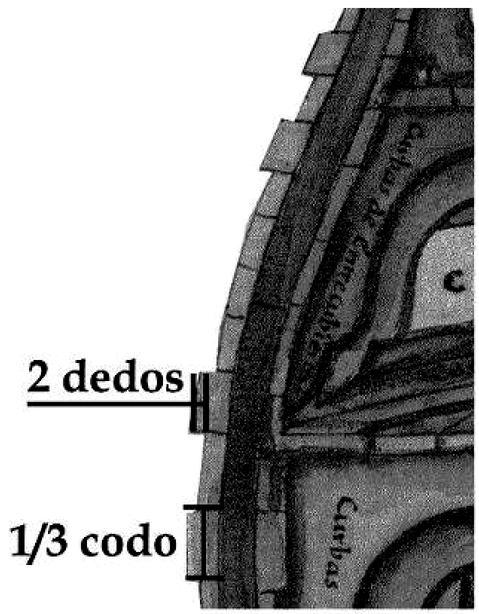

Figure 4- 4. Wales (*cintas*) as specified by the 1607 ordinances**.**

It was also regulated that from 1610 onwards the vessels participating in the *Carrera de Indias* had to be of 567 *toneladas* or smaller. By regulating the tonnage in this manner, the Spanish crown intended to counteract the problem of entering and departing Seville through the shallows of the San Lúcar River and of the port of San Juan de Ulúa, Veracruz, while at the same time ensuring that the loading and unloading of the cargo was done faster and that the appraisal of the fleets was done faster and with a reduced cost.[17]

As mentioned above, the ordinances also regulated the manner in which the vessels were to be loaded and their tonnage calculated in order to serve in the fleets of the *Carrera de Indias*. This calculation was done by a representative from the *Casa de la Contratación*, a person of "science and consciousness that could recognize, observe, and consider what each vessel could carry based on its measurements."[18] This representative was sent to inspect the process of loading the cargo for the fleets. He was in charge of marking with iron indicators the stem post and the sternpost of the vessel being appraised and registered the distance, in *codos*, from the waterline to the markings, and from the markings to the helm port. These indicators served as limits that assured that the vessels did not take more than the specified freight. If the vessel was overloaded, its owner would lose half the value of the cargo.

The representative from the *Casa de la Contratación* was also in charge of registering all the measurements used for the calculation of tonnage, by means of the following rules:[19]

1. The *codo* used to take all the measurements had to be of 2/3 of a *vara* plus 1/32 [of that 2/3 of the *vara*], which was the *codo de ribera*.
2. The maximum beam (*manga*) had to be measured at the main mast's hatch and at the level of the main deck, from port to starboard, including the width of the master frame and up to the inner face of the hull's planking (*de tabla a tabla*) (Fig. 4-5).
3. The depth in hold (*puntal*) had to be measured from the ceiling planking on flat of the floor of the master frame to the ceiling planking of the main, or lower deck, where the maximum beam was measured (Fig 4-5). To avoid fraud, the ceiling planking had to be cleaned so that the limber board could be seen. It was also advised that for measuring the depth in hold of the *urcas* and vessels of the Levant it was necessary to remove a board of the ceiling planking and to place over the floor a plank of 1/8 of a *codo* (0.07 m). The depth in hold was measured over this plank. This was done because the type of vessels mentioned above might have the ceiling planking higher than required. Additionally, if the main deck was above the maximum beam, the value of the depth in hold would not be given more than "what was required by the proper rules of proportion."[20] The rule of proportion was explained through the example that if the vessel had 16 *codos* (9.2 m) of beam, then the depth in hold had to be calculated at 9 *codos* (5.2 m); if the vessel had 18 *codos* (10.4 m) of beam, the depth in hold had to be calculated at 10 ½ *codos*

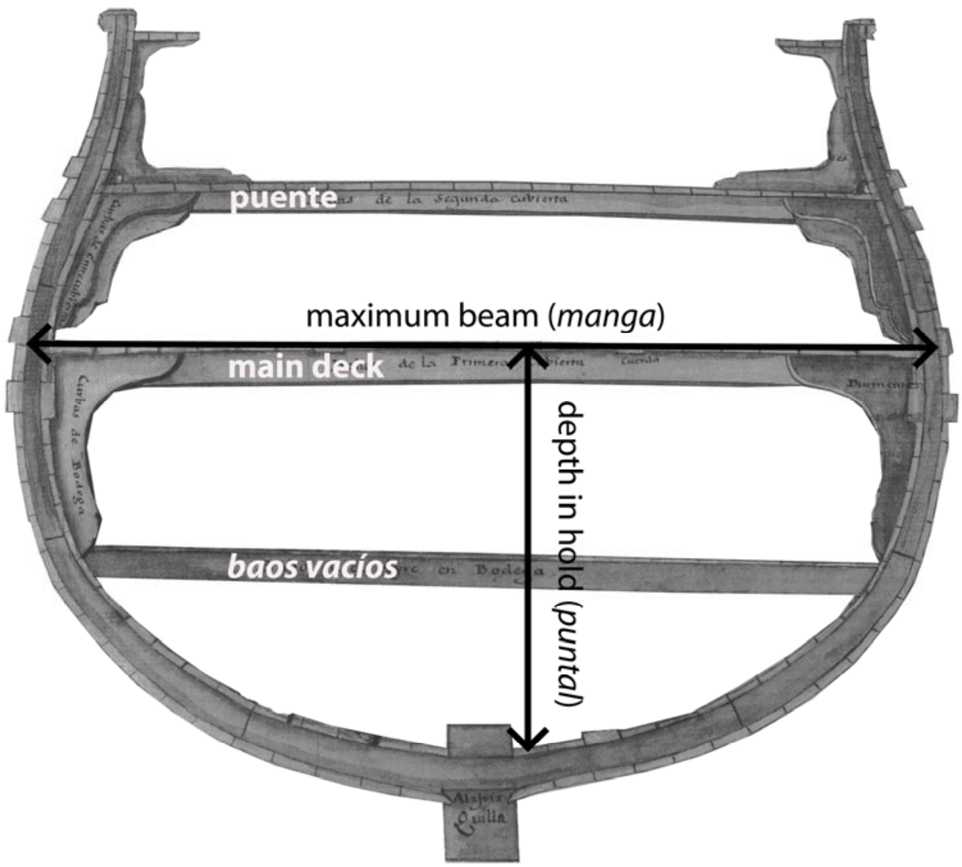

Figure 4- 5. Location of the maximum beam (*manga*) and depth in hold (*puntal*) as specified by the 1607 ordinances.

(6 m), and the same was done for larger and smaller vessels. The relation between the beam and the depth in hold equaled about 1: 0.57. If the vessels had the main deck below the maximum beam, the measurement was taken from the flat of the floor to the main deck.

4. Like the maximum beam, the overall length (*eslora*) was not to be measured "on the air" (*al aire*). Instead, it had to be measured over the main deck, from the stem post to the sternpost, including their molded dimension. (Fig. 4-1).

The 1607 ordinances do not provide a formula for the calculation of tonnage based on the measurements. The only thing mentioned is that 5 percent had to be subtracted from the result obtained from all the multiplications because of the runs, and that if the vessel had 2 decks and its tonnage was more than 100 *toneladas*, then 20 percent had to be added to the result.

Tonnage was probably calculated in one of the following two ways:

1. In 1590, King Philip II had regulated that the tonnage was to be calculated based on the method used by Cristóbal de Barros. He added the depth in hold (P) to half the beam (m), and divided the result by 2. The amount obtained was squared and multiplied by the overall length (E). The result was divided by 8 to convert cubic *codos* to *toneladas*. If the law was still enforced by 1607, this formula would have been used, although the way in which the measurements were taken was different. Previously the measurements were

taken at the height of the highest breadth, whether this was at the level of the main deck or not (*al aire*).

$$\frac{E\left(\frac{P+(m)}{2}\right)^2}{8} = toneladas$$

2. If the previous law was no longer in use, the tonnage could have been calculated by using the formula described by Tomé Cano in his 1611 treatise:

$$0.95\left(\frac{E \times m \times P}{8}\right) = toneladas$$

This formula already included the subtraction of 5 percent mentioned in the 1607 ordinances.

Ordenanzas para la fábrica de navíos de guerra y mercantes – 1613

The second ordinances were expedited at San Lorenzo on July 6, 1613, invalidating the previous ones of 1607. Currently, a copy of theses ordinances is housed at the General Indies Archive in Seville, catalogued as *Indiferente, no° 2595*. The document was transcribed by historian José Luis Serrano Mangas in an appendix of his book *Función y evolución del galeón en la Carrera de Indias*.[21]

In the transcription made by Serrano Mangas, the 1613 ordinances were made up of 106 articles. The first 15 articles contained information about the new measurements that were to be used for the construction of the vessels. Articles 16 through 20 discussed the manner in which the hulls were to be assembled, and articles 21 through 72 talked about the structural reinforcement of the hulls. The following 20 articles, from the 73rd to the 92nd, contained information about the rigging of the vessels. Articles 93 through 101 referred to the tools that were to be used in shipbuilding and discussed the shipbuilders' payroll. The last 5 articles, from the 102nd to the 106th, established the way in which the ordinances were to be applied.

Like the previous ordinances, the 1613 ordinances gave measurements for the depth in hold, the keel, the overall length, and the entries and runs; locations and dimensions of the decks and the castles were also given. To this list of measurements, the new ordinances added the measurements for the flat of the floor (*plan*), the spring of the stem post (*lanzamiento a proa*) and rake of the sternposts (*lanzamiento a popa*), the wing transom (*yugo*) (Table 6), the deadrise (*astilla muerta*), the outward tilt of the futtocks at mid-ship's and tail frames (*joba*) (Table 7), and the sheer of the decks (*arrufadura de la cubierta*) and the wales (*arrufadura de las cintas*) (Table 8). The new ordinances also included the number of pre-designed frames (Table 6). The addition of these measurements was intended to provide better proportioned vessels in all sections of the hull, while at the same time obtaining a greater degree of standardization.

The new ordinances gave measurements for 15 vessels. In contrast to the 1607 ordinances that classified the vessels into *navíos*, *galeoncetes*, and galleons, the vessels of the 1613 ordinances were classified into *pataches*, *navíos*, and galleons.

The three *pataches* described through the different measurements ranged from 8 to 10 *codos* of beam. The three *navíos* ranged from 11 to 13 *codos* of beam. Finally, the nine galleons ranged from 14 to 22 *codos* of beam.

The *pataches* were small, fast vessels used by the *armadas* to delegate orders, to announce the arrival of the fleets, and to probe for shallows. Due to their size, the measurements for the *pataches* smaller than 8 *codos* of beam were left to the choice of the shipbuilder, as long as these did not surpass any of the measurements given in the ordinances.[22]

The first *patache* for which measurements are given is that of 8 *codos* (4.6 m) in beam. This vessel did not have either a forecastle, or a stern castle, but rather only a small cabin at the stern. The main deck rose at 3 ¾ *codos* (2.2 m) above the ceiling planking of the hold (*soler or granel*). The tonnage for this *patache* was recorded at 55 *toneles machos*. To obtain this tonnage 5 percent was subtracted form the calculations, but 20 percent was not added because it only had one deck.

The second *patache*, of 9 *codos* (5.2 m) of beam, had the main deck at a height of 4 *codos* (2.3 m) over the ceiling planking. The upper works of this vessel included a small forecastle and a stern castle (*a media tolda*), which meant that rather than having the poop deck extend up to the main mast, it extended only half the distance to the main mast. The tonnage of this vessel was of 70 *toneles machos*; 5 percent was added to the calculations but, like the previous one, 20 percent was not added.

The third and last *patache*, of 10 *codos* (5.8 m) of beam, had the main deck at a height of 4 ½ *codos* (2.6 m). Like the *patache* of 9 *codos* of beam, this vessel had a small forecastle and an aftcastle (*a media tolda*). The tonnage for this *patache* was calculated at 94 ½ *toneles machos*, following the same reasoning used for the previous two.

The first *navío*, of 11 *codos* (6.3 m) of beam, had the main deck at a height of 5 *codos* (2.9 m). If this vessel was built as a merchantman, a second deck or *puente* was constructed. The second deck was located 3 *codos* (1.7 m) above the main deck. If the vessel was built to serve in the *armadas*, it had only the main deck, the forecastle and the aft castle. The tonnage of a merchantmen was calculated at 148 *toneladas*, including the 20 percent added because of the second deck. Since the equivalent warship did not have a second deck, the 20 percent would not have been added and because of this the vessel only had 118 2/5 *toneladas*.

Starting from the *navío* of 12 *codos* (6.9 m) of beam, the new ordinances established a difference, both in the location of the main deck and in the calculation of tonnage, based on whether the vessels were to serve as merchantmen or as warships. For all the previously mentioned vessels, the main deck was located at the point where the height of the depth in hold reached the maximum beam. For vessels of 12 *codos* of beam or above that were built as merchantmen, the same rule was applied; but when such vessels were built to serve in the *armadas*, the main deck was constructed ½ a *codo* (0.29 m) above the location of the maximum beam. As for the difference in tonnage, the warships, which had all the other measurements equal to those of the merchantmen, were rated at a higher tonnage because the main deck rose that ½ *codo* (0.29 m) above the beam (Table 6).

The second deck and the upper works for the vessel of 12 *codos* of beam and larger were done in the following way:

1. The *navío* of 12 *codos* (6.9 m) of beam had the 2nd deck at a distance of 2 1/3 *codos* (1.3 m) measured from the ceiling planking of the main deck to the upper face of the upper deck beam, and the fore and aft castles 2-2/3 *codos* (1.5 m) above the 2nd deck when built as a warship. When built as a merchantman, the 2nd deck rose 2-2/3 *codos* (1.5 m) above the main deck and was to be furnished only with a cabin at the stern.
2. The *navío* of 13 *codos* (7.5 m) of beam and the galleons of 14 (8 m), 15 (8.6 m), and 16 *codos* (9.2 m) of beam had the 2nd deck at a height of 3 *codos* (1.7 m) above the main deck, measured the same way as the previous vessel. The same value was used whether the vessels were merchantmen or warships. No height is mentioned for the aft and forecastles of any of these vessels.

   The 14 *codos* of beam galleon was furnished with a cabin at the stern and a forecastle. The galleon of 15 *codos* of beam was furnished with a forecastle and an aft castle (*a media tolda*) which included a poop cabin and a small cabin for the helmsman. If this vessel was used as a merchantman the stern castle could extend all the way to the main mast. The galleon of 16 *codos* of beam had a forecastle and an aft castle (*a media tolda*).
3. The galleons of 17 (9.8 m) and 18 *codos* (10.4 m) of beam had a distance of 3-1/8 *codos* (1.7 m) and 3-1/6 *codos* (1.8 m) respectively between the 1st and

2nd decks. Both galleons had fore and stern castles, with poop cabins located under the poop deck, and a helmsman's cabin on the poop deck.

4. The 2nd deck for the galleons of 19 (10.9 m), 20 (11.5 m), 21 (12.1 m), and 22 *codos* (12.7) of beam was 3-¼ *codos* (1.9 m) above the main deck. All such galleons had forecastles and stern castles, which extended all the way to the main mast, with a poop cabin under it and a helmsman's cabin on the poop deck.

The ordinances of 1613 also provided detailed information about the timbers used to construct and reinforce the decks, and included their measurements (Table 9). The main deck of all the vessels had to be built using *baos* (larger deck beams) and *latas* (smaller deck beams). The *latas* were set at a distance of 1/3 of a *codo* (0.19 m) from each other.[23] Every third beam had to be reinforced with a hanging knee.[24] The *cuerdas* (carlings) placed under the beams had the same dimensions as the *latas*. A second set of *cuerdas* was placed over the *baos*.[25] The dimensions of the *trancaniles* (waterways) depended on the tonnage of the vessels.[26] The gun ports were located 1 *codo* (0.575 m) above this main deck and measured 1 ¼ *codos* (0.72 m) per side.[27] The second deck (*puente*) was built with similar timbers as those used in the main deck.

The frames at the second deck had to close or narrow as much as the frames had opened at the *baos vacíos* (orlop deck) located at 3-½ *codos* (2 m) under the main deck (Fig 4-6). The top timbers had to be straightened above the second deck to create more space for the artillery.[28]

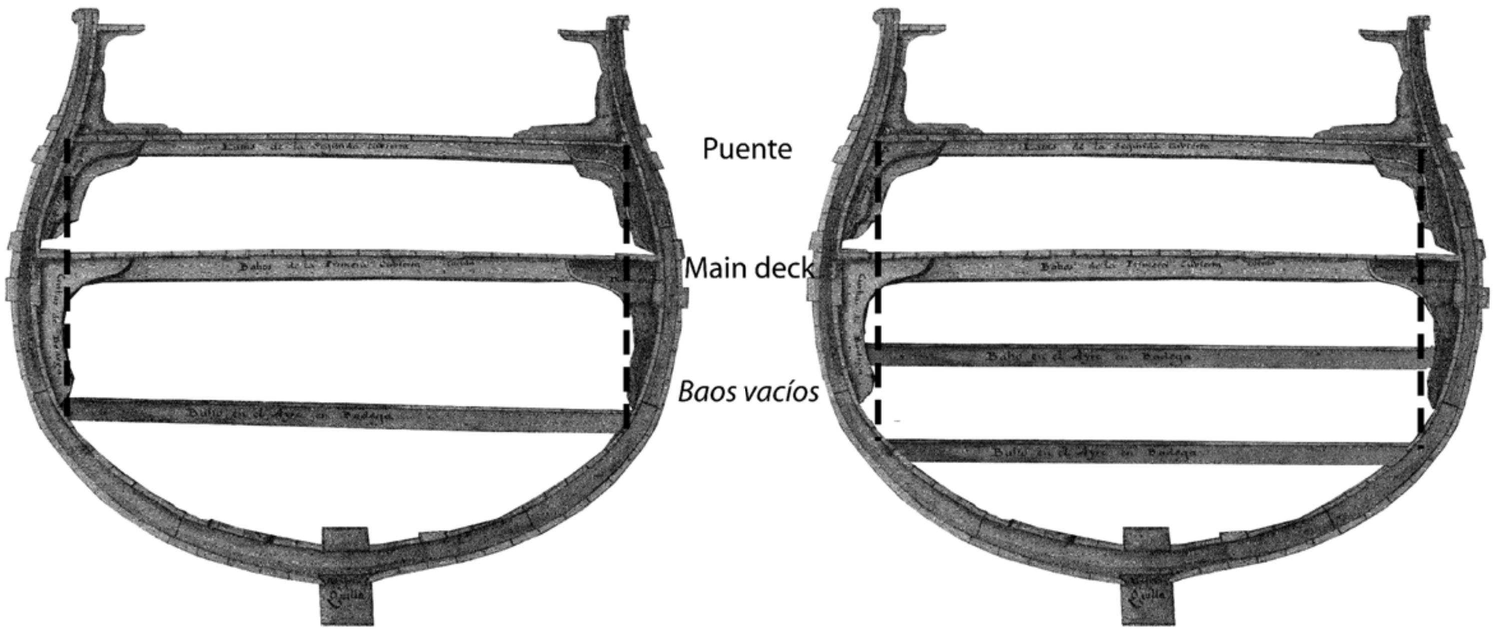

Figure 4- 6. Narrowing of the frame at the second deck and location of the baos vacíos according to the 1613 ordinances.

If the vessels had fore and stern castles, the deck beams had to be of ¼ of a *codo* (0.14 m) sided and 1/6 of a *codo* (0.10 m) molded.[29] The *durmientes* (shelf clamps) supporting these beams had to measure 1/5 of a *codo* (0.12 m) sided and 1/3 of a *codo* (0.19 m) molded.[30]

The maximum beam, as mentioned before, was measured at different locations based on whether the vessel was a merchantman or a warship. For the merchantmen the beam was measured at the height of the main deck, and for the warships it was measured half a *codo* (0.29 m) below the main deck (Fig 4-7). However, in all vessels the beam was measured from starboard to port up to the side of the frame, not including the thickness of the hull planking. About this measurement, it was ordered in article 17 that if due to the weight of the timbers the beam opened half a *codo* (0.29 m) more than that specified in the list of measurements, the vessel would not be considered faulty.[31]

In all these ships the depth in hold was half of the beam. The ordinances established that the measurement had to be done up to the main deck, but was not mentioned if it was to be done from the keel or from the ceiling planking. Historian Rubio Serrano explains that because the 1613 ordinances for the calculation of tonnage gave the measurement of the depth in hold from the ceiling planking to the main deck, the measurement given by the ordinances had to be interpreted like so (Fig 4-7).[32]

The vessels smaller than 19 *codos* (10.9 m) of beam were required to have an orlop deck, made of a line of unplanked beams (*baos vacíos*), situated at half of the

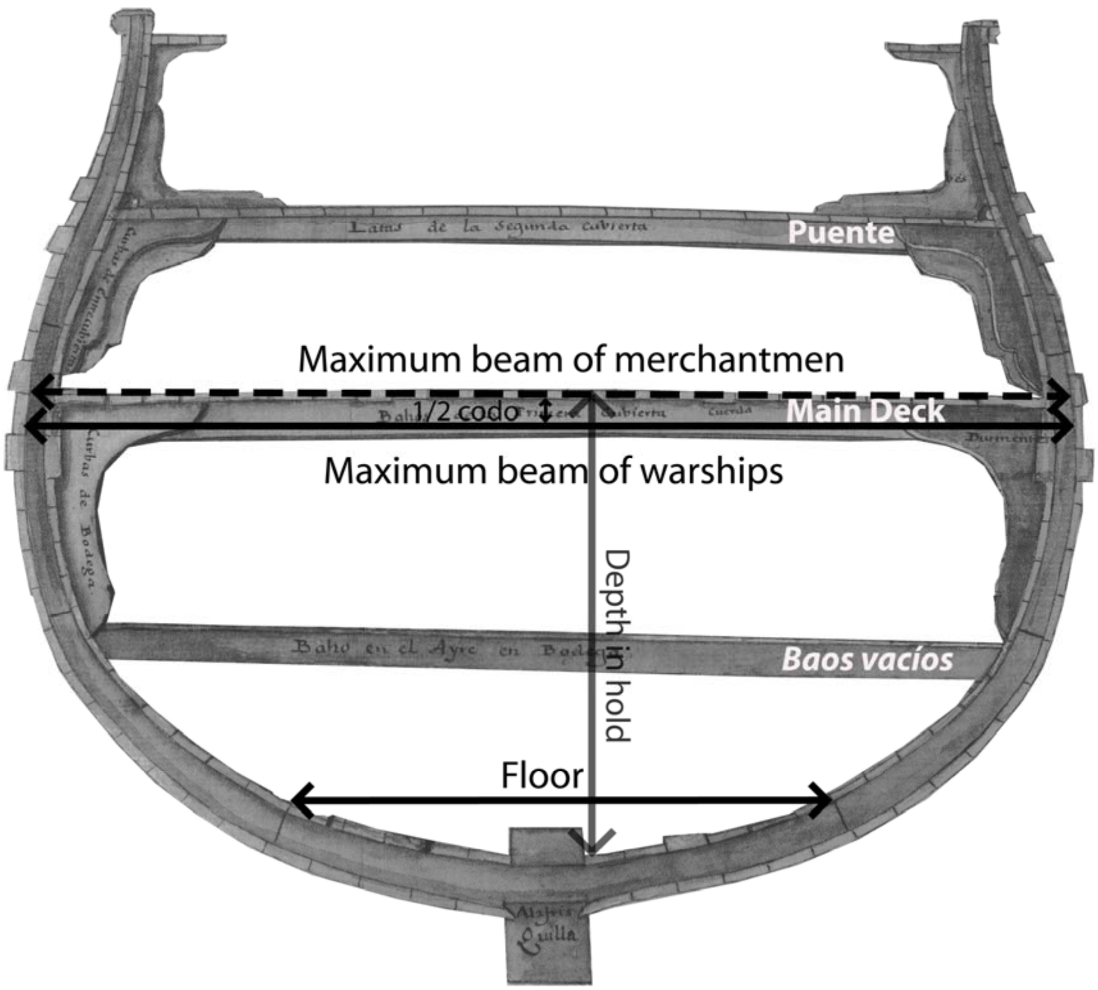

Figure 4- 7. Location of the maximum beam (*manga*), floor (*plan*), and depth in hold (*puntal*) as specified by the 1613 ordinances.

height of the depth in hold (1/4 of the beam). However, if the vessels were of 20 *codos* (11.5 m) of beam or larger, two levels of unplanked beams were required. In order to situate them properly, the depth in hold was divided so that the levels were placed at the same distance between them, and from the floors and the main deck (Fig 4-6).[33]

Regarding the proportion between the beam and the keel, the formula used to obtain the length of the keel used by Juan de Veas' *nueva fábrica* and described by Tomé Cano in his treatise could be applied, as explained by Rubio Serrano, to the vessels of 13 to 18 *codos* of beam.[34] According to the formula, the length keel of the vessels of 12 *codos* of beam or smaller had to be 3 times the beam. For the vessels larger than 12 *codos* of beam, the following formula was used:

$$(12 \times 3) + [(\text{beam of the vessel} - 12) \times 2].$$

The 1613 ordinances only applied the second part of the formula in order to obtain the length of the keel. As a result, the length of the keel for the vessel of 8 to 18 *codos* of beam was obtained through the following arithmetic progression, where M is the beam and Q the length of the keel, and the numeric values are expressed in *codos*:

$$2M + 12 = Q$$

For the vessels of 19 to 22 *codos* of beam, the length of the keel could not be obtained with the above formula. Rather, a discontinuity in the arithmetic progression occurred: for the vessels of 19, 20, and 21 *codos* of beam, instead of adding 12 *codos* to twice the beam, 11 *codos* were added, or

$$2M + 11 = Q$$

The length of the keel of the 22 *codos* of beam vessels was obtained by subtracting yet another *codo* from the formula, or:

$$2M + 10 = Q$$

These reductions were implemented in order to obtain a length of keel that was better proportioned to the measurement of the beam, but avoiding a keel larger than necessary or with compromised structural strength.

The overall length was measured from the stem post to the sternpost at the level of the main deck. This measurement was obtained from the addition of the rakes of the posts and the length of the keel. In contrast to the 1607 ordinances, the 1613 ordinances did include the values of the rakes of both the stern and stem posts. The spring of the stem post was approximately ½ of the beam, and the rake of the sternpost was ½ of the spring of the stem post or about ¼ of the beam. In this way, the overall length in all vessels equaled to the length of the keel plus ¾ of the beam (Fig 4-8).

The heights of the runs as they hit the posts were also given in the new ordinances (Fig 4-8). The entries or fore-runs should equal 1/3 of the beam, and the aft-runs should be ½ of the fore-runs, or 1/6 of the beam.

The flat of the floor timber was measured on the ceiling planking of the master frame (Fig. 4-7). Its measurement was, on all vessels, ½ of the beam.

The wing transom (*yugo*) was proportional to the beam in the same way as the flat of the floor, measuring ½ of the beam. The fashion pieces (*aletas*) opened at the location of the wing transom ½ of the beam, and it was specified that 2 or 2 ½ *codos* (1.1 -1.4 m) below the wing transom, the fashion pieces should open ¼ of a *codo* (1.4 m)

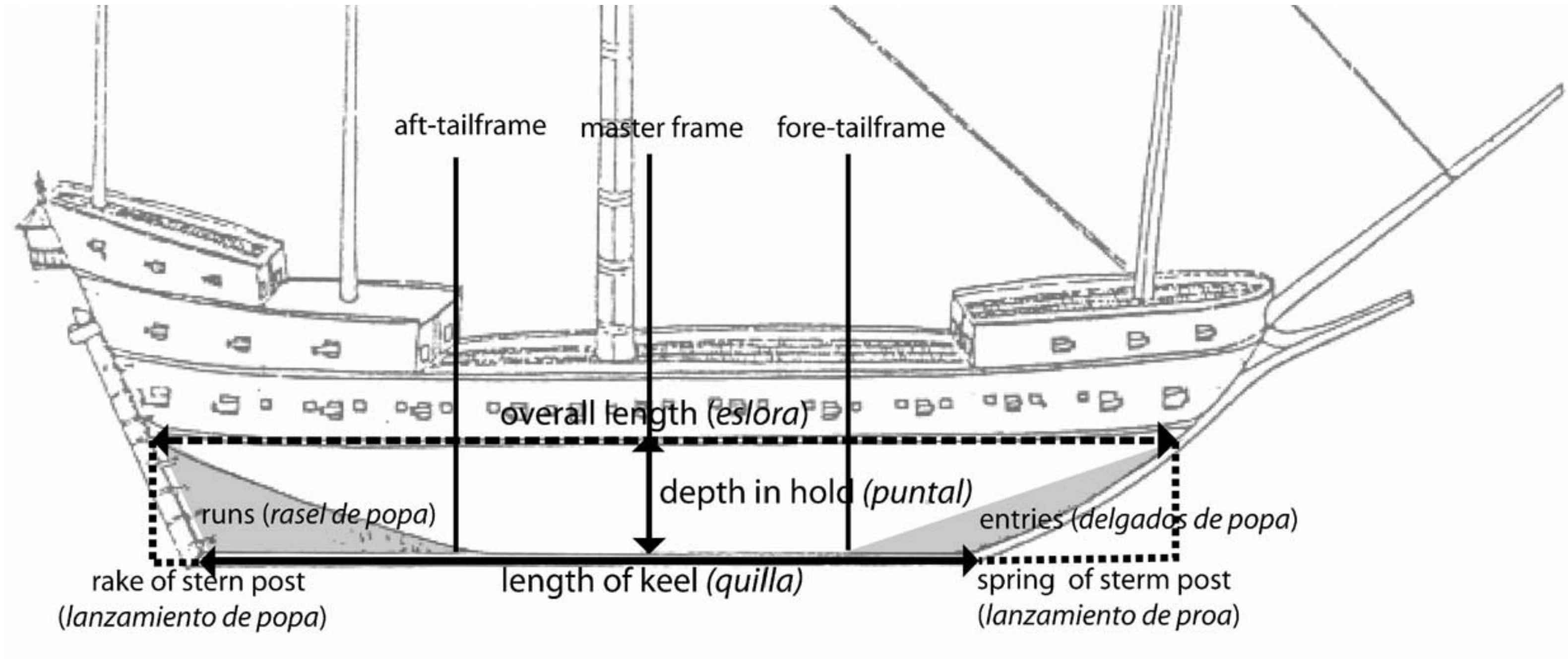

Figure 4- 8. Measurements given by the 1613 ordinances.

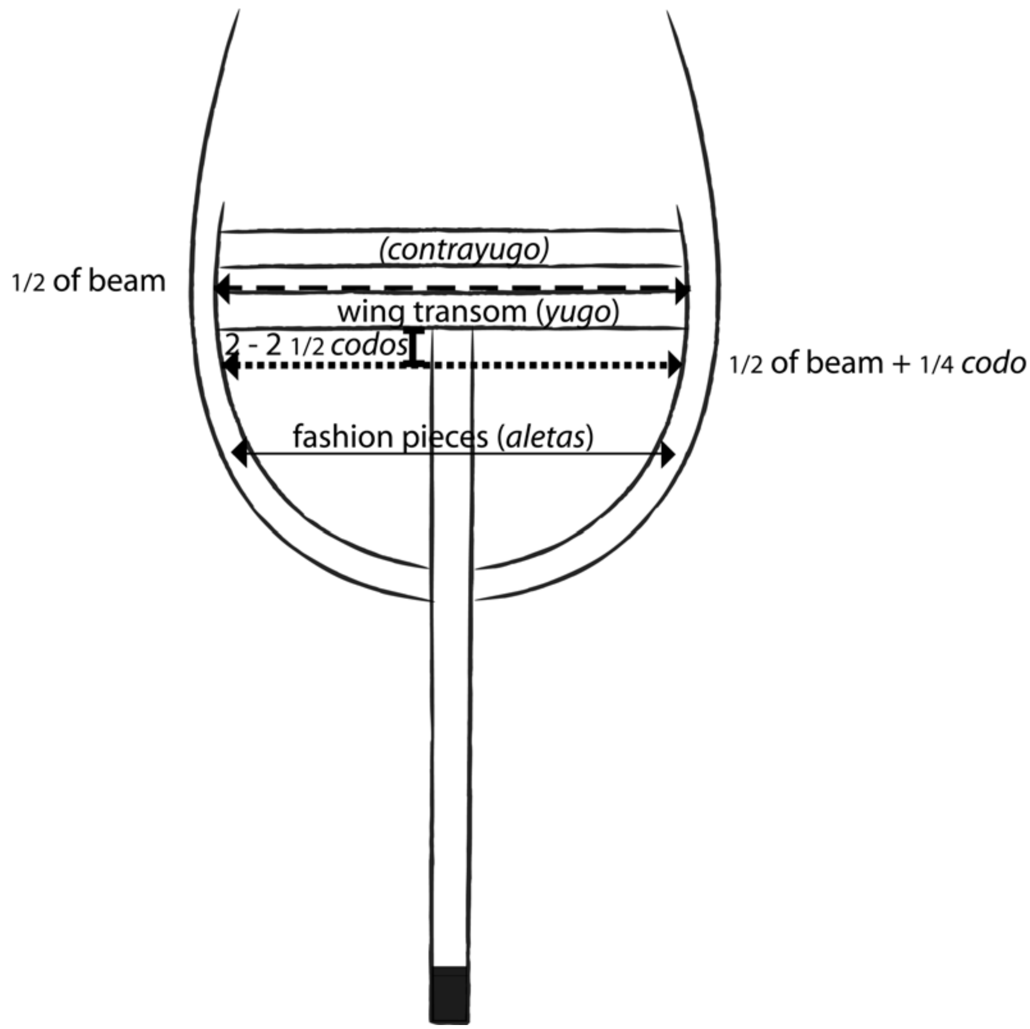

Figure 4- 9. Specifications for the wing transom (*yugo*) and fashion pieces (*aletas*) according to the 1613 ordinances.

more, with the purpose of getting a rounder stern (Fig 4-9).[35] Even though the ordinances did not provide the height at which the wing transom had to be placed, it was safe to assume that it would go 2 ½ *codos* (1.4 m) above the main deck, because the helmport (*lemera*) was placed at that height.[36]

The deadrise (*astilla muerta*), which was the height measured from the top of the keel to the top of the flat of the floors at the turn of the bilge, was calculated by taking the fraction of a *codo* specified for each vessel and dividing it into three parts (Table 7). Two parts were given to the master frame, so that the master frame had 1/16 of the beam in the *astilla muerta*. The remaining part had to be divided in as many parts as the number of pre-designed frames fore and aft of the master frame of each vessel. For example, if the vessel had a total of 24 square body frames, 12 fore and 12 aft of the master frame, the remaining part would be divided by 12: proportional increments, which were obtained with a geometrical algorithm, such as the *mezza-luna*. The 2 parts of *astilla muerta* given to the master frame plus the result of the division of the remaining part were added in increments to the pre-designed frames (Fig. 4-10 and 4-11) (Table 7).

The process of tilting the futtocks outwards at midships and tail frames (*joba*) used the same fraction of a *codo* as the deadrise with the difference that the fraction was divided into as many parts as the number of pre-designed frames after the second frame fore of the master frame (Table 7). Half of that fraction was divided into as many parts as the number of pre-designed frames from the sixth frame aft of the master frame (Fig 4-12) (Table 7).

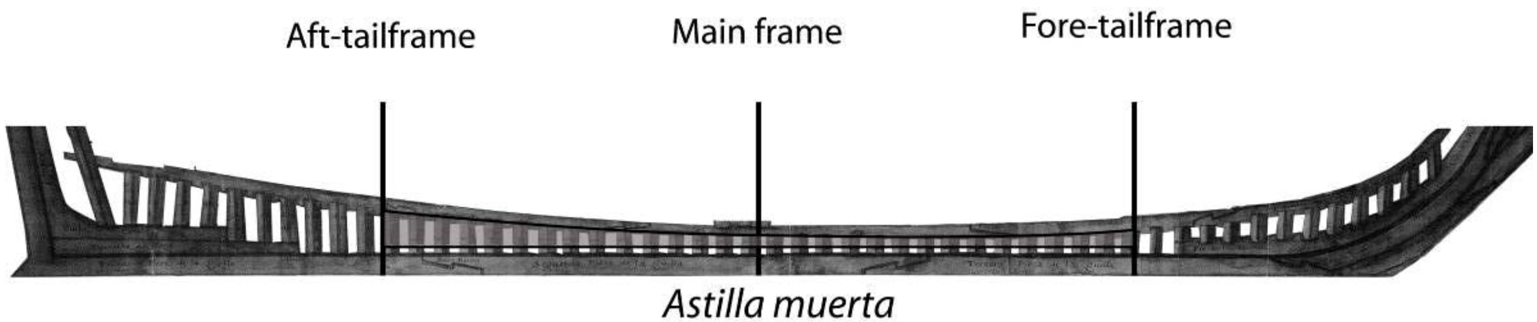

Figure 4- 10. Deadrise (*astilla muerta*).

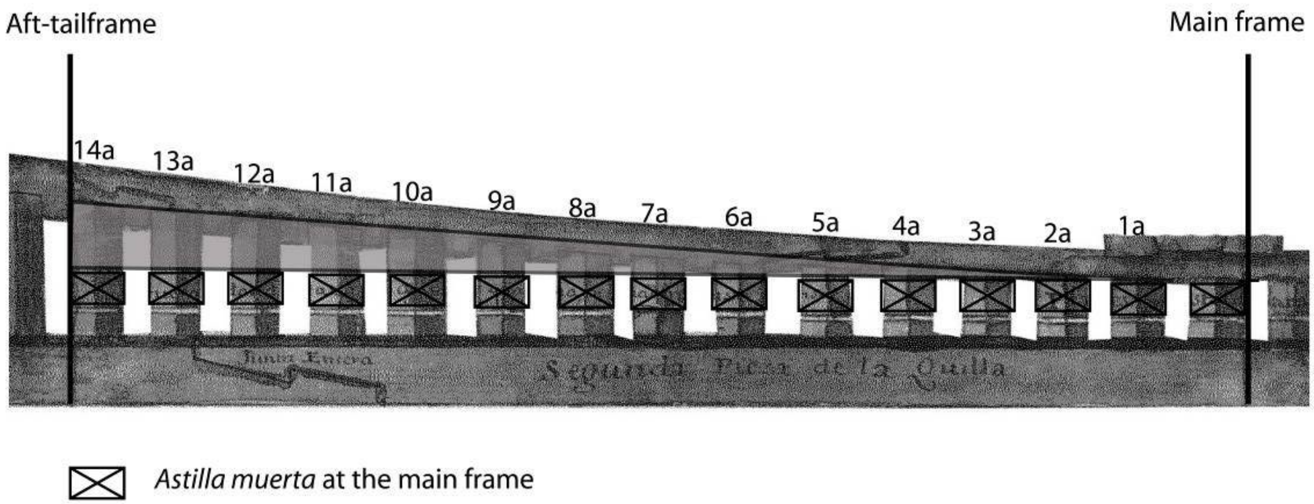

Figure 4- 11. Deadrise (astilla muerta) as specified by the 1613 ordinances. a = fraction of the deadrise divided by the number of frames.

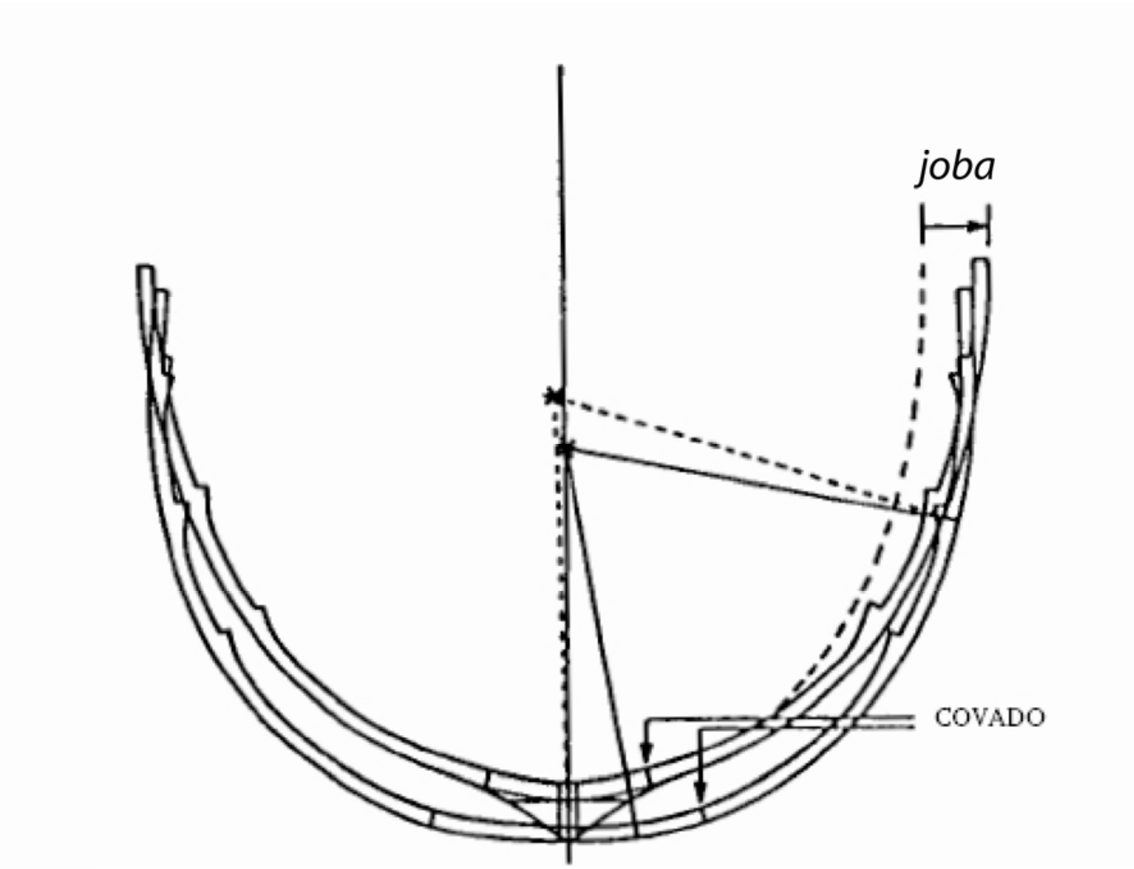

Figure 4- 12. Process of tilting the futtock outwards at midships and tail frames (*joba*). (After Loewen 2001, 244)

The ordinances also specified how the tail frames were to be placed. For this purpose, a string was swung to extend the overall length (at the level of the main deck, from the stem post to the sternpost). The string was then folded by half and then by half again, resulting in ¼ of the overall length. The string was then placed at the tip of the rake of the stem post, parallel to the keel. One *codo* (0.575 m) was then added to the point above the keel were the string reached, and the fore tail frame was set at that location. The string would be used the same way at the stern of the vessel, but 2 *codos* (1.1 m) were added to the extension of the string over the keel. The aft tail frame was set into place at that distance. The pre-designed frames were placed between these two tail frames (Fig. 4-8).

Article 19 also referred to the tail frames. This article specified that the flat of the floors of the tail frames had to measure ½ of the measurement of the master frame's floor plus 1/25 of the *grúa*. The total value of the *grúa* equaled half the flat of the floor, and was measured from the turn of the bilge point to the center of the keel on the master frame (Fig. 4-13). It also dictated that due to the runs, the beam at the fore tail frame had to be 1 *codo* (0.575 m) less than that of the master frame, and the beam at the aft tail frame had to be 2 *codos* 1.1 m) smaller than that of the master frame.[37]

The sheer of the main deck was the same for all the vessels. The measurement given was of 1/2 *codo* (0.28 m) at the bow and 1 *codo* (0.575 m) at the stern. Because the measurement was the same for all vessels, the sheer would have been more extreme for vessels of lesser tonnage.[38]

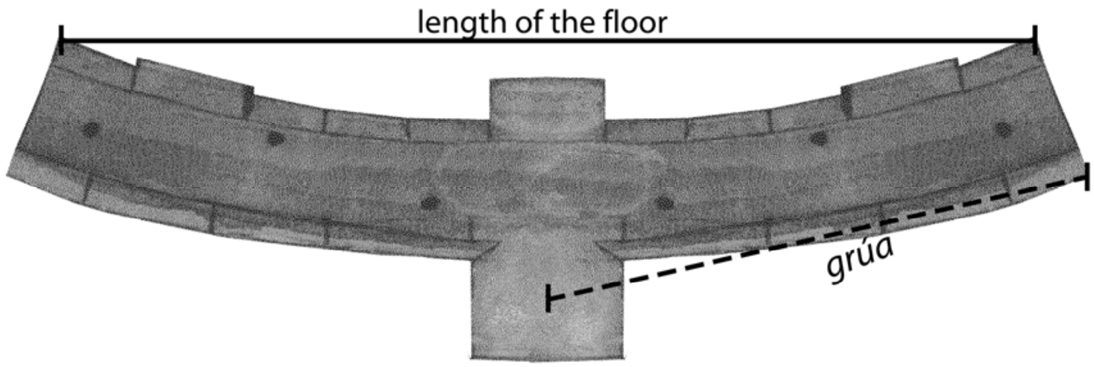

Figure 4- 13. Definition of *grúa* according to the 1613 ordinances.

The sheer of the wales, as specified by the ordinances, varied according to the beam of the vessel, but the location of the wales was the same for all vessels (Table 8). The first wale was located 1 *codo* (0.575 m) under the main deck. The second was placed at the head of the deck beams, running parallel to the shelf clamp. Both these wales were doubled. Their scantlings were 2/3 of a *codo* (0.38 m) molded and 1/3 of a *codo* (0.19 m) sided. The third wale was simple, and placed above the gunports or 2 ½ *codos* (1.4 m) above the main deck.[39]

A final specification of the 1613 ordinances pertained to the thickness of the hull's planking (Table 10). For all vessels, the thickness of the hull's planking was divided into three sections. The first section, where the planking was the thickest, was from the keel up to the 2nd wale. The second section was at the main deck. The third section was for the planking above the main deck. For this last section, it was only specified that the thickness had to be reduced gradually based on the thickness provided for the main deck.

The 1613 ordinances were to enter into effect at the moment of their publication. To make sure that they were followed, it was ordered that anybody wanting to build a vessel had to get a list of measurements from the superintendent of the district. A fine of ¼ of the value of the cargo would be charged if a vessel were found with measurements different from those provided by the ordinances. Furthermore, of the vessels that had been built prior to the publication of the ordinances, only those that had measurements that were similar to those required could be admitted in the navigation of the *Carrera de Indias*.

The publication of these ordinances included a list of ship types prohibited from navigation "in the fleets, or by themselves, to Santo Domingo, Havana, Puerto Rico, Jamaica, Campeche, or any other port of the Indies":[40]

1. Frigates, caravels, fustas, urcas, flyboats, or any type of foreign vessels, even when owned by Spaniards, unless there was a shortage of national vessels.
2. Any vessel that surpassed 17 *codos* of beam (539 ¼ *toneladas*), or that had a height of the depth in hold of more than 8 ½ *codos* (4.9 m).
3. Any vessel that had a third deck that connected from the stern to the forecastles, or a second deck built the same way when the vessel was not required to have one (*puente corrida*).
4. Any vessels with the beam extended through the addition of longitudinal strakes (*embones* or *contracostados*), a method equivalent to the English furring, although only planking was added to the outside of the hull.

The last regulation of the 1613 ordinances mentioned that when private vessels that followed the measurements were to be taken for the *Armadas del Mar Océano* and the Mediterranean, the owner of the vessel would be paid 9 *reales* per *tonelada* every month. That payment took into consideration the cost of building vessels that followed the new rules, and the benefit of having them in the *armadas* due to their perfection and strength.

Ordenanzas para el arqueamiento de navíos – 1613

As mentioned above, the 1613 ordinances do not include a section on the calculation of the tonnage. Instead, a separate ordinance was decreed for this purpose, which was passed three months later, on October 19, 1613. A copy of these ordinances can be found at the General Archive of Simancas, under the *Guerra y Marina* collection, document 3146.

According to this revised ordinance, five measurements were taken into account for the calculation of tonnage: the beam, the depth in hold, and the overall length (which were the basis for calculating the tonnage according to the 1607 ordinances) plus the measurements of the keel and the flat of the master frame. Based on such measurements, three ways of calculating the tonnage are given.

The depth in hold (P) was calculated from the top of the keel to the level of the first (lower) deck. The beam (M) was calculated amidships, also at the level of the lower deck. The overall length (E) was again measured at the first deck, from the inner face of the stem post to the inner face of the sternpost. The flat of the floor (F) is the flat portion on the base of the master frame.

1. Under the assumption that the depth in hold (P) was half the value of the beam (M), the first way for calculating tonnage was done by multiplying the beam by half the depth in hold. The result was then multiplied by ½ of the sum of the

overall length (E) and the keel (Q), and then divided by 8 (to change the result from cubic *codos* to *toneladas*).

$$(\text{if } P = M/2) \rightarrow [MP/2 \times (1/2 \times (E+Q))]/8 \quad [1]$$

If the depth in hold was more or less than half of the beam, the tonnage was calculated in the following way:

a) If $P < M/2$, then the depth in hold was subtracted from half of the beam, the result divided by 2, and added to the beam. This new value of the beam (M_1) was then entered in equation [1] above.

b) If $P > M/2$, then half of the beam was subtracted from the depth in hold, the result divided by 2, and added to the beam. This new value of the beam (M_2) was then entered in equation [1] above.

$$(\text{if } P < M/2) \rightarrow [M_1P/2 \times (1/2 \times (E+Q))]/8 \quad [2]$$

$$(\text{if } P > M/2) \rightarrow [M_2P/2 \times (1/2 \times (E+Q))]/8 \quad [3]$$

2. Under the assumption that the flat of the floor (F) was half the value of the beam (M), the second way for calculating tonnage was done by multiplying the beam by half the flat of the floor (F). The result was then multiplied by ½ of the sum of the overall length (E) and the keel (Q), and then divided by 8 (to change the result from cubic *codos* to *toneladas*).

$$(\text{if } F = M/2) \rightarrow [MF/2 \times (1/2 \times (E+Q))]/8 \quad [4]$$

If the flat of the floor (F) was more or less than half of the beam (M), the tonnage was calculated the following way:

a) If F < M/2, then the flat of the floor was subtracted from half of the beam, the result divided by 2, and added to the beam. This new value of the beam (M_1) was then entered in equation [4] above.

b) If F > M/2, then half of the beam was subtracted from the flat of the floor, and the result added to the beam. This new value of the beam (M_2) was then entered in equation [4] above.

$$(\text{if } F < M/2) \rightarrow [M_1 F/2 \times (1/2 \times (E+Q))]/8 \quad [5]$$

$$(\text{if } F > M/2) \rightarrow [M_2 F/2 \times (1/2 \times (E+Q))]/8 \quad [6]$$

3. And the third way was done by adding ¾ of the beam to ½ flat of the floor and then multiplying the result by ½ of the sum of the length and the keel. Again, the total was divided by 8 to convert cubic *codos* into *toneladas*.

$$[(\tfrac{3}{4} M + \tfrac{1}{2} F) \times (1/2 (E+Q))]/8 \qquad [7]$$

The rules to calculate ship's tonnages were established by the 1613 ordinances; however, the ordinances of 1618 have no section regulating tonnage, and the existence of a separate ordinance for calculating tonnage is not known. The 1618 ordinances, rather, focused on the change in design measurements.

Ordenanzas para la fábrica de navíos de guerra y mercantes – 1618

The last ordinances of this naval reform were published in Madrid on June 16, 1618. A copy of these ordinances was included in a compilation of laws for the *Carrera de Indias* that was published by Julián de Paredes in Madrid in 1680.[41] The 4th edition of the *Recopilación de las Leyes de los Reynos de las Indias*, originally published in 1759, was more recently republished in 1943. The 1618 ordinances can be found in Volume III, Title 28, Law xxii of the latter publication.[42]

Like the 1613 ordinances, the 1618 ordinances were divided into 106 articles. The first 14 regulated the measurements of the vessels. The rules for the construction and structural strengthening of the vessels were given from article 15 through article 71. The following 20 articles, 72 through 91, regulated the rigging of the vessels. Ten articles, 92 to 101, were dedicated to the payroll of the shipbuilders and the tools that were to be used at the shipyards. The last 6 articles, 102 to 106, established the manner in which the ordinances were to be applied.

An important difference presented by the 1618 ordinances was the change of terminology used for the classification of the vessels. Previously, these had been described by specific names based on the dimension of their beam and their tonnage, in *pataches*, *galeoncetes*, *navíos* and galleons. In the new ordinances, the 14 vessels described, from 9 to 22 *codos* of beam, were defined under the general concept of *navío*. This term, as explained by Veitia and Linage, included all ocean going vessels of large capacity and strong enough to withstand open sea navigation. By using this term, it was intended to homogenize the concept of the Spanish vessels for the *Carrera de Indias*.

Another important difference in the study of the trends of the sets of ordinances was that the 1618 ordinances did not differentiate merchantmen from warships. The 1613 ordinances established a difference between the two by locating the main deck at different heights and by calculating the tonnage based on the use of the vessel. Without this difference, the 1618 ordinances reinstated the concept of a multiuse vessel where the new measurements were intended as those of the "perfect vessel".

Only three new specifications were added to the list of measurements provided by the 1613 ordinances. These additions were the dimensions of the outer sternpost (*contracodaste*), the location of the bitt (*bita*), and the regulation that the fashion piece had to be rounded like the scarf of the flat of the floor and the futtock in the master frame. Because the 1618 ordinances described the same elements in terms of measurements, the members of the council were able to focus principally on the change of values (Table 11).

The lengths of keel, when compared to the lengths provided by the 1613 ordinances, were reduced by 2 *codos* (1.1 m). This meant that rather than using the length of the keel of the 12 *codos* of beam *navío* as a base to calculate the length of the keel of all the other vessels, the length of the keel of the 10 *codos* of beam *navío* was used. In other words, the length of the keel (Q) for the *navíos* of 9 to 18 *codos* of beam was calculated by multiplying the beam (M) by 2 *codos*, but instead of adding 12 *codos* to the result as specified by the 1613 ordinances, the 1618 ordinances only added 10 *codos* (5.8 m):

$$2M + 10 = Q$$

Then, the length of the keel of the *navíos* of 19, 20, and 21 *codos* of beam was calculated by subtracting 1 *codo* to the previous formula:

$$2M + 9 = Q$$

Finally, the length of the keel of the *navío* of 22 *codos* of beam was calculated by reducing the addition by yet another *codo*:

$$2M + 8 = Q.$$

The depth in hold no longer measured half the beam nor was measured from the decks to the keel. Rather, it was the height at which the maximum breadth was placed. The 1618 ordinances gave an approximate beam to depth in hold ratio of 1: 0.45 on all vessels.

The maximum beam of the vessel was still being placed at the height of the depth in hold, but the main deck was no longer located at the meeting point of these two elements. The main deck now had to be placed ½ a *codo* (0.29 m) above the maximum beam (Fig. 4-14). Because the height of the depth in hold was reduced, the main deck was still located at a height equal to that of half the beam. And so, the methods for the calculation of tonnage as specified by the 1613 ordinances for the calculation of tonnage could still be applied.

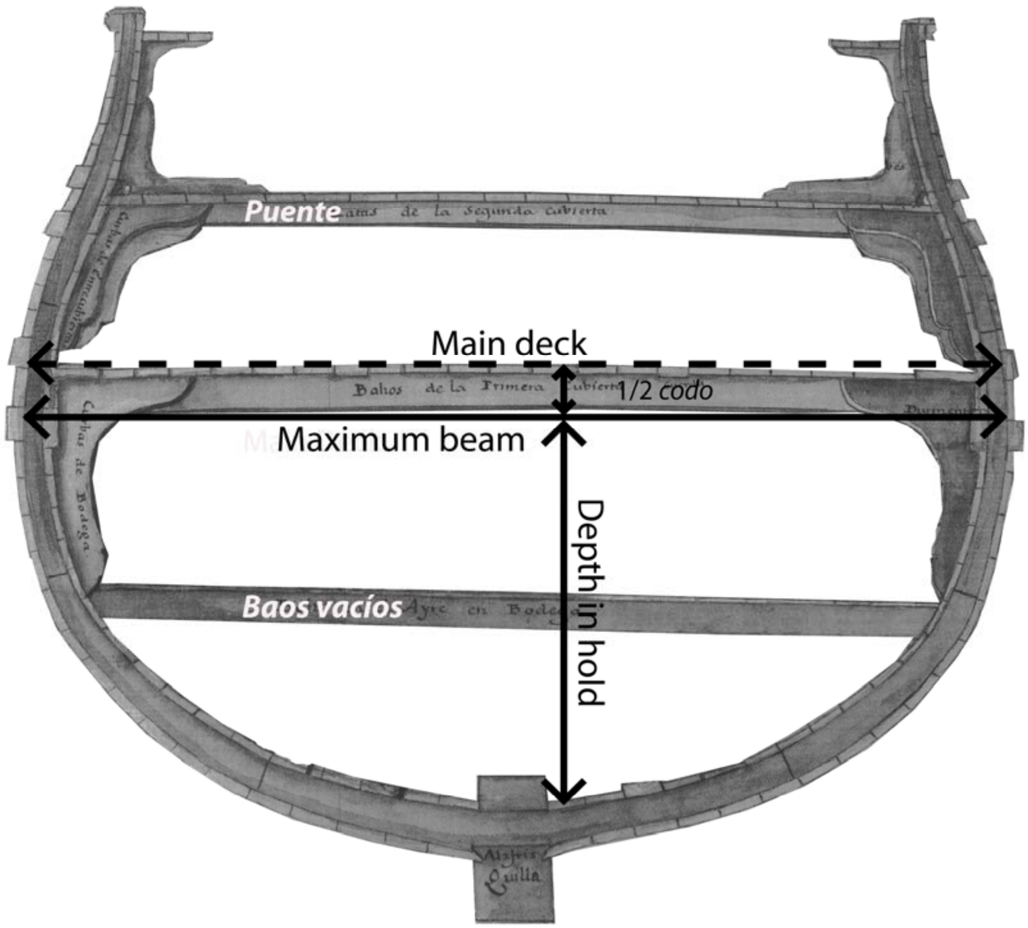

Figure 4- 14. Location of the maximum beam (*manga*) and depth in hold (*puntal*) as specified by the 1618 ordinances.

The *navío* of 9 *codos* (5.2 m) of beam was in fact a *patache*, having only the main deck and no fore or aft castles. The *navío* of 10 *codos* (5.8 m) of beam was not equipped with a second deck either, but it did have a small forecastle and an aft castle (*a media tolda*). A second deck was added starting with the *navío* of 11 *codos* (6.3 m) of beam. This second deck was placed 3 *codos* (1.7 m) above the main deck, and it had 2 steps (*quebrados*), one fore and one aft. The *quebrados* were placed 1 ½ *codos* (0.86 m) above the second deck. The aft and forecastles rose 3 *codos* (1.7 m) above the *quebrados*. The vessels of up to 16 *codos* (9.2 m) of beam followed the same specifications. The remaining *navíos*, from 17 to 22 *codos* (9.8 – 12.7 m) of beam, had the second deck also at 3 *codos* (1.7 m) above the deck, but the *quebrados* were only 1 *codo* (0.575 m) above the second deck. The fore and aft castles were 3 *codos* (1.7 m) above the *quebrados*.

The height of the entries as they hit the stem post measured 1/3 of the beam. Instead of dividing these in half to obtain the measurement of the runs, as it was required by the 1613 ordinances, the height of the runs as they hit the sternpost was 1/3 of the entries.

The measurement of the wing transom also changed. The 1613 ordinances stipulated that the wing transom measure ½ the beam. The 1618 ordinances added ¼ of a *codo* (0.14 m) to the previous measurement.

The amount of deadrise (*astilla muerta*) was calculated in the same way as ordered in the 1613 ordinances. Two parts of the value were given to the master frame, and the remaining third was divided into as many parts as the number of pre-designed frames of the vessel. The change, again, was done to the actual value provided (Table 12).

The outward tilt of the futtocks at midships and tail frames (*joba*) was still the same value as the deadrise, but the manner in which the value was divided changed. The 1618 ordinances specified that the value given had to be divided into as many parts as the vessels had frames after the second frame forward of the master frame (Table 12). Half of that value was divided to obtain the height of the after section. This half was divided into equal parts. The number of parts depended on the size of the vessel: for the *navíos* of 9 to 11 *codos* of beam it would be divided based on the number of pre-designed frames starting at the 6th frame aft of the master frame; for the *navíos* of 12 and 13 *codos* of beam starting at the 7th frame; for the *navíos* of 14 to 16 *codos* of beam starting at the 8th frame; for the *navíos* of 17 and 18 *codos* of beam starting at the 9th frame aft; for the *navíos* of 19 and 20 *codos* of beam starting on the 10th frame; and for the remaining vessels starting at the 11th frame.

It is important to note that not all the design measurements were changed. The following specifications remained the same: the flat of the floor, being half of the beam; the spring and rake of the stem and sternposts, adding together about ¾ of the beam; and the sheer of the main deck, giving ½ a *codo* (0.29 m) at the bow and 1 (0.575 m) at the stern.

All the specifications for building and the hull structure, including the dimensions of the various timbers, also remained the same as those provided by the 1613 ordinances.

The publication of the 1618 ordinances concluded Philip III's naval reform. Through the ordinances, the Spanish crown addressed the necessity to standardize shipbuilding in order to make it easier to deal with the new demands of the Indies trade, especially in terms of protection. Without a standing navy, the standardization of the vessels and manner in which their tonnage was calculated would have allowed the state to create *armadas* with leased vessels at a faster pace, while being assured that the vessels were properly suited for war. At the same time, standardization would have provided the state with a closer control of the trade system, since it would be easier and faster to calculate the amount of merchandise that each vessel could carry safely, the proper taxes on the cargo, and the *avería* for the protection of the fleets.

ENDNOTES CHAPTER IV

[1] AGS, *Guerra y Marina*, leg. 640, n° 21

[2] Ibid.

[3] AGS, *Guerra y Marina*, leg. 669, no 10

[4] MNM, *Colección Vargas Ponce*, vol. III, doc. 43, pgs 211-13

[5] AGS, *Guerra y Marina*, leg. 644, no 726.

[6] Ibid.

[7] Fernández Duro 1880, 55

[8] AGS, *Guerra y Marina*, 3146, November 19, 1612.

[9] AGS, *Guerra y Marina*, 3146, May 22, 1613

[10] Fernández Duro 1880, 56

[11] Ibid, 56-8

[12] Phillips 1986, 31

[13] AGS, *Guerra y Marina*, 776, October 18, 1612.

[14] Ibid.

[15] Navarrete 1971

[16] Ordenanzas 1607, 586

[17] Ibid, 586

[18] Ibid, 586

[19] Ibid, 587-9

[20] Ibid, 589

[21] Ordenanzas 1613, 211-36

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[22] Ibid, 222, article 16

[23] Ibid, 224, article 32

[24] Ibid, 225, article 35

[25] Ibid, 225, article 34

[26] Ibid, 224, article 33

[27] Ibid, 226, article 43

[28] Ibid, 223, article 20

[29] Ibid, 227, article 53

[30] Ibid, 227, article 54

[31] Ibid, 222, article 17

[32] Rubio Serrano 1991, 2: 75

[33] Ordenanzas 1613, 224, article 29

[34] Rubio Serrano 1991, 2: 80

[35] Ordenanzas 1613, 226, article 40

[36] Rubio Serrano 1991, 2: 76

[37] Ordenanzas 1613, 222-3

[38] Rubio Serrano 1991, 2: 80

[39] Ordenanzas 1613, 227, articles 55, 56

[40] Ibid, 233, article 104

[41] This publication was recently digitalizad by the University of Seville.
http://fondosdigitales.us.es/books/digitalbook_view?oid_page=261979 .
The 1618 ordinances can be found at:
http://fondosdigitales.us.es/books/digitalbook_view?oid_page=267283

[42] Ordenanzas 1618

CHAPTER V

CONCLUSIONS

Throughout the 16th century Spain maintained its position as Europe's largest naval power, and with the annexation of Portugal in 1580, the volume of trade only increased. "Together, the two Iberian crowns had about 300,000 tons of shipping, considerably more than the Dutch at 232,000, and out of sight of lesser shipping powers such as France and England."[1] However, by the beginning of the 17th century Spain entered into a long period of economic depression due to a prolonged crisis in production and population at home, and the increasing expenditure that resulted from maintaining its position in Europe. This depression threatened Spain's maritime power.[2]

A possible solution, as seen by the Spanish crown, was the standardization of shipbuilding and calculation of tonnage methods in the Iberian Peninsula. The *ordenanzas para la fábrica de navíos de guerra y mercantes*, after careful consideration, were first published in 1607 with the intention of gaining better control over the volume of merchandise transported through the *Carrera de Inidas*, obtaining the proper dues over it, and facilitating the embargo of vessels for the crown's armadas, while at the same time settling all discussions on the matter of the "ideal" Spanish vessel.

On the topic of shipbuilding, these regulations specified the measurements of the five main design elements used by Spanish shipbuilding: the beam (*manga*), keel (*quilla*), overall length (*eslora*), depth in hold (*puntal*), and the flat of the floor (*plan*), with the addition of the runs (*rasel*). These measurements were given for 13 vessels, three *navíos*, two *galeoncetes*, and eight galleons, which ranged consecutively from 10 to 22 *codos* in beam. In addition to these measurements, and to further standardize the vessels, the ordinances specified how the hull structure of all vessels had to be constructed.

The measurements given by the 1607 ordinances were not accepted by merchants, who argued that the vessels were faulty and better suited as warships; built with an average beam/keel/ length ratio of approximately 1: 2.6: 3.3 and a beam to depth in hold ratio of 1: 0.55, when the typical merchant vessel of that period had a beam/keel/length of less than 1: 2.5: 3.2.[3] Added to their discontent with the proportions of the vessels established by the crown was the regulation that only vessels of 567 *toneladas* or smaller could participate in the *Carrera*. For this reason, the ordinances were amended and a new set of ordinances was published in 1613.

Intending to further standardize Iberian vessels, the new ordinances added new design elements to the list of measurements provided by the 1607 ordinances, while at the same time revising the previous measurements. Likewise, the articles containing information on how the hulls were to be constructed became more specific. Another important change was in the types of vessels that were included in the ordinances.

Fifteen vessels, ranging from 8 to 22 *codos* of beam, were now described in the 1613 ordinances: three *pataches*, three *navíos*, and nine galleons. For each vessel, in addition to the elements given by the 1607 ordinances, a value was given for the spring and rake of the stem post (*lanzamiento a proa*) and sternpost (*lanzamiento a popa*), the wing transom (*yugo*), the deadrise (*astilla muerta*), the outward tilt of the futtocks at midships and tail frames (*joba*), and the sheer of the decks (*arrufadura de la cubierta*) and wales (*arrufadura de las cintas*), and the number of pre-designed frames.

The 1613 ordinances decreased the tonnage of the vessels that could participate on the *Carrera de Indias* to 539 ¼ *toneladas*. At the same time, following aspects of Veas' *nueva fábrica*, the new ordinances increased the beam/keel/length ratio to 1: 2.8: 3.6, and reduced the beam to depth in hold ratio to 1: 0.5. These changes were done under the assumption that by having a longer keel, the depth in hold could be reduced while still creating ample space for merchandise.[4] The fore and aft castles were also reduced in order to make the vessels more stable.

Based on these changes merchants still argued that the vessels were better suited for war, and refused to follow the ordinances. A new set of ordinances was published in 1618 as a means to conciliate with the merchants' requirements.

This time there were no major changes in the design elements specified, but rather in the actual value proposed for the elements and in the nomenclature of the vessels. The 1618 ordinances described 14 vessels, all under the classification of *navíos*, ranging from 9 to 22 *codos* of beam. The beam/keel/length ratio was reduced to 1: 2.7: 3.4, while the beam to depth in hold remained the same, at 1: 0.5. Because of this reduction of proportions and the increase of tonnage of vessels that could participate in the *Carrera* to 624 *toneladas*, merchants accepted the 1618 ordinances as a compromise with the crown.

With the last set of ordinances, Philip III's naval reform would come to an end. The 1618 ordinances and the 1613 *ordenanzas para el arqueamiento de navíos* were added to a long list of regulations to keep the *Carerra de Indias'* functioning properly and ended the discussion on the subject of shipbuilding and calculation of tonnage for the time being.

ENDNOTES CHAPTER V

[1] Phillips 1986, pg 8

[2] Ibid, pg 8

[3] Odriozola Oxardibe 1998, pg 97

[4] Ibid, pg 97

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APPENDIX A

TABLES

Table 1. **Measurements provided in the *Diálogo entre un vizcaíno y un montañés sobre la fábrica de navíos*.** H1= depth in hold at maximum breadth, H2= depth in hold, L1= spring of stempost, L2= raking of sternpost, R1= entries, R2= runs. All measurements in *codos*.

	Beam	Keel	Length	H1	H2	Floor	L1	L2	R1	R2	Transom	1st Deck	*Puente*
1. Galleon	22	66	80 2/3	11	12	11	11	3 2/3	8 1/3	1 5/6	11	12	3 1/2
2. Galleon	21	63	77	10 1/2	11 1/2	10 1/2	10 1/2	3 1/2	8	1 3/4	10 1/2	8 1/2	3 1/2
3. Galleon	20	60	73 1/2	10	11	10	10	3 1/3	7 2/3	1 2/3	10	8	3 1/2
4. Galleon	19	57	69 2/3	9 1/2	10 1/2	9 1/2	9 1/2	3 1/6	7 1/3	1 3/5	9 1/2	7 1/3	3 1/2
5. Galleon	18	54	66	9	10	9	9	3	7 1/5	1 1/2	9	7	3 1/2
6. Galleon	17	51	62 1/2	8 1/2	9 1/2	8 1/2	8 1/2	3	6 2/3	1 3/7	9	6 1/2	3 1/2
7. Galleon	16	48	58 2/3	8	9	8	8	2 2/3	6 1/3	1 1/3	8	6 1/4	3 1/2
8. Galleon	15	45	55	7 1/2	8 1/2	7 1/2	7 1/2	2 1/2	6	1 1/4	7 1/2	5 3/4	2 1/2
9. Galleon	14	42	51	7	8	7	7	2 1/4	5 2/3	1 1/4	7	5 3/4	2 1/2
1. Patache	13	39	46 2/3	7	7 1/2	6 1/2	6 1/2	2 1/4	5 1/2	1 1/2	6 1/2	5 1/2	X
2. Patache	12	36	44	X	7	6	6	2	X	X	X	5	X
3. Patache	11	33	41 1/12	6 1/2	7 1/4	5 1/2	5 1/3	1 3/4	4 2/3	X	5 1/2	4 3/4	X
4. Patache	10	30	36 1/3	5 1/2	7	5	5	1 2/3	4 1/2	1	5	4 1/2	X

Table 2. Measurements from the 1st Committee of Santander for the galleons of the Armada de la Guarda de la Carrera de Indias – 1581. All measurements in *codos*.

	Beam	**Keel**	**Length**	**Depth in hold**	**1st Deck**	***Puente***	***Jareta***
Pero Menéndez 1568	12 - 13	30	44	7 1/2	4	3 1/2	3 1/2
1st Committee of Santander 1581	*	37 - 38	*	8 3/4	5 3/4	3	3 1/4

Table 3. Measurements from the Committee of Seville for the galleons of the Armada de la Guarda de la Carrera de Indias – 1581. All measurements in *codos*.

	Beam	**Keel**	**Length**	**Depth in Hold***	***Baos Vacíos***	**1st Deck**	***Puente***
Capitana and Almiranta	16 1/2	36	55	11	4 1/2	3 1/4	3 1/4
Other Galleons	15	33	50	10 1/4	4	3	3 1/4

* Depth in hold measured to the *puente.*

Table 4. Measurements from the 2nd Committee of Santander for the galleons of the Armada de la Guarda de la Carrera de Indias – 1581. All measurements in *codos*.

	Beam	**Keel**	**Length**	**Depth in Hold***	***Baos Vacíos***	**1st Deck**	***Puente***
Capitana and Almiranta	16	35	56	11	4	3 1/2	3 1/2
Other Galleons	15	34	52	9 1/2	3	3	3 1/2

* Depth in hold measured to the *puente*.

Table 5. Measurements provided by the 1607 ordinances. All measurements in *codos* unless otherwise specified.

	Beam	Keel	Length	Depth in Hold	Runs	Tonnage*
1. Navío	10	29	38	5 1/2	3 1/4	151 1/2
2. Navío	11	33	40	6	3 1/2	178 3/4
3. Navío	12	36	43	6 1/2	3 3/4	238 1/4
1. Galeoncete	13	37	48	7	5	297 5/8
2. Galeoncete	14	39	50	7 1/2	5 1/4	373 3/8
1. Galleon	15	40	52	8	5 1/2	487 1/8
2. Galleon	16	42	57	8 3/4	5 3/4	567 7/8
3. Galleon	17	43	60	9 1/4	6	669 3/8
4. Galleon	18	44	62	9 1/2	6 1/2	755
5. Galleon	19	47	65	10	6 3/4	897 3/8
6. Galleon	20	48	69	10 1/2	7	1033
7. Galleon	21	51	72	11	7 1/4	1184 5/8
8. Galleon	22	53	75	11 1/2	7 1/2	1351 5/8

* *Toneladas*

Table 6. Measurements provided by the 1613 ordinances. R1= entries, R2= runs, L1= spring of stempost, L2= raking of sternpost, # of frames include the master frame. All measurements in *codos* unless otherwise specified.

	Beam	Keel	Length	Depth in Hold	Floor	R1	R2	L1	L2	# of Frames	Transom	Tonnage: Merchant	Tonnage: Armada
1. Patache	8	28	33 3/4	3 3/4	4	2 1/2	1 1/4	4	1 3/4	25	4	**55***	
2. Patache	9	30	36	4	4 1/2	3	1 1/2	4	2	27	4 1/2	**75 ½***	
3. Patache	10	32	38 3/4	4 1/2	5	3 1/3	1 2/3	4 1/2	2 1/4	29	5	**94 ½***	
1. Navío	11	34	41 1/2	5	5 1/2	3 2/3	1 5/6	5	2 1/2	31	5 1/2	148†	
2. Navío	12	36	45	6	6	4	2	6	3	31	6	207 3/4†	214†
3. Navío	13	38	47 3/4	6 1/2	6 1/2	4 1/3	2 1/6	6 3/4	3	33	6 1/2	258 1/8†	268†
1. Galleon	14	40	50 1/2	7	7	4 2/3	2 1/3	7 1/4	3 1/4	35	7	316†	325 3/8†
2. Galleon	15	42	53 1/4	7 1/2	7 1/2	5	2 1/2	7 3/4	3 1/2	35	7 1/2	381 3/4†	393 1/8†
3. Galleon	16	44	56	8	8	5 1/3	2 2/3	8	4	37	8	456†	479 3/4†
4. Galleon	17	46	58 3/4	8 1/2	8 1/2	5 2/3	2 5/6	8 1/2	4 1/4	37	8 1/2	539 1/4†	555 1/4†
5. Galleon	18	48	61 1/2	9	9	6	3	9	4 1/2	39	9	632†	651†
6. Galleon	19	49	63 1/4	9 1/2	9 1/2	6 1/3	3 1/6	9 1/2	4 3/4	39	9 1/2	721 3/4†	743†
7. Galleon	20	51	66	10	10	6 2/3	3 1/3	10	5	41	10	833 5/8†	858 5/8†
8. Galleon	21	53	68 3/4	10 1/2	10 1/2	6 2/3	3 1/3	10 3/4	5	41	10 1/2	956 3/8†	985†
9. Galleon	22	54	70 1/2	11	11	7	3 1/2	11 1/2	5	43	11	1073 1/3†	1105 1/2†

* *Toneles machos*
† *Toneladas*

Table 7. Deadrise (*astilla muerta*) and outward tilt of the futtocks at midships and tail frames (*joba*) as provided by the 1613 ordinances. F1 = Number of frames from the 2nd fore and aft of the mainframe, F2 = Number of frames from the 2nd fore of the mainframe, F3 = Number of frames from the 6th aft of the mainframe. All measurements in *codos*.

	Astilla	***Astilla* Mainframe**	***Astilla* / F1**	**F1**	***Joba***	***Joba* / F2**	**F2**	***Joba* / F3**	**F3**
1. Patache	1/2	1/3	1/6	12	1/2	1/2	12	1/4	7
2. Patache	1/2	1/3	1/6	13	1/2	1/2	13	1/4	8
3. Patache	5/8	3/7	1/5	14	5/8	5/8	14	1/3	9
1. Navío	11/16	1/2	2/9	15	11/16	11/16	15	1/3	10
2. Navío	3/4	1/2	1/4	15	3/4	3/4	15	3/8	10
3. Navío	13/16	1/2	1/4	16	13/16	13/16	16	2/5	11
1. Galleon	7/8	3/5	2/7	17	7/8	7/8	17	4/9	12
2. Galleon	7/8	3/5	2/7	17	15/16	15/16	17	1/2	12
3. Galleon	1	2/3	1/3	18	1	1	18	1/2	13
4. Galleon	1	2/3	1/3	18	1 1/16	1 1/16	18	1/2	13
5. Galleon	1	2/3	1/3	19	1 1/16	1 1/16	19	1/2	14
6. Galleon	1 1/8	3/4	3/8	19	1 1/8	1 1/8	19	4/7	14
7. Galleon	1 1/4	5/6	3/7	20	1 1/4	1 1/4	20	5/8	15
8. Galleon	1 1/4	5/6	3/7	20	1 1/4	1 1/4	20	5/8	15
9. Galleon	1 3/8	1	1/2	21	1 3/8	1 3/8	21	2/3	16

Table 8. Sheer of the main deck and wales according to the 1613 ordinances. All measurements in *codos*.

		Sheer of main deck		Sheer of wales	
	Beam	**at Bow**	**at Stern**	**at Bow**	**at Stern**
1. Patache	8	1/2	1	1	1 1/2
2. Patache	9	1/2	1	1	1 1/2
3. Patache	10	1/2	1	1 1/2	2
1. Navío	11	1/2	1	1 1/2	2
2. Navío	12	1/2	1	1 1/2	2
3. Navío	13	1/2	1	2	2 1/2
1. Galleon	14	1/2	1	2	2 1/2
2. Galleon	15	1/2	1	2	2 1/2
3. Galleon	16	1/2	1	2	2 1/2
4. Galleon	17	1/2	1	2	2 1/2
5. Galleon	18	1/2	1	2	2 1/2
6. Galleon	19	1/2	1	2	2 1/2
7. Galleon	20	1/2	1	2 1/2	3
8. Galleon	21	1/2	1	2 1/2	3

Table 9. Dimensions of the timbers used in the construction of the decks according to the 1613 ordinances. All measurements in *codos*.

Main deck		**Molded**	**Sided**
	Baos	1/4	1/3
	Latas	1/5	1/3
	Cuerdas	1/5	1/3
	*Cuerdas (*2nd set*)*	1/4	1/4
		Thickness	**Width**
	Durmientes (shelf clamps)	1/4	1/2
	Contradurmientes (clamps)	1/4	1/4
Puente		**Molded**	**Sided**
	Baos	1/4	1/3
	Latas	1/6	1/3
	Cuerdas	1/5	1/3
	*Cuerdas (*2nd set*)*	1/4	1/4
		Thickness	**Width**
	Durmientes (shelf clamps)	1/4	1/2
	Contradurmientes (clamps)	1/4	1/4

Table 10. Thickness of the hull planking as specified by the 1613 ordinances. All measurements in *codos*.

	Beam	**Up to 2nd wale**	**At main deck**
1. Patache	8	1/9	1/10
2. Patache	9	1/9	1/10
3. Patache	10	1/9	1/10
1. Navío	11	1/8	1/9
2. Navío	12	1/8	1/9
3. Navío	13	1/7	1/8
1. Galleon	14	1/7	1/8
2. Galleon	15	1/6	1/7
3. Galleon	16	1/6	1/7
4. Galleon	17	1/5	1/6
5. Galleon	18	1/5	1/6
6. Galleon	19	1/5	1/6
7. Galleon	20	1/5	1/6
8. Galleon	21	1/5	1/6
9. Galleon	22	1/5	1/6

Table 11. **Measurements provided by the 1618 ordinances.** R1= entries, R2= runs, L1= spring of stempost, L2= raking of sternpost, # of frames include the master frame. All measurements in *codos* unless otherwise specified.

	Beam	Keel	Length	Depth in Hold	Floor	R1	R2	L1	L2	# of Frames	Transom	Tonnage†
1. Navío	9	28	34	4	4 1/2	3	1	4	2	25	4 1/2	80 3/4
2. Navío	10	30	36	4 1/2	5	3 1/3	1 1/9	4	2	27	5	106 1/8
3. Navío	11	32	39	5	5 1/2	3 2/3	1 2/9	4 3/4	2 1/4	29	5 1/2	157
4. Navío	12	34	41 1/2	5 1/2	6	4	1 1/3	5	2 1/2	31	6	198
5. Navío	13	36	45	6	6 1/2	4 1/3	1 4/9	6	3	31	6 1/2	251
6. Navío	14	38	48	6 1/2	7	4 2/3	1 5/9	7	3	33	7	409 1/2
7. Navío	15	40	50 1/2	7	7 1/2	5	1 2/3	7 1/4	3 1/4	35	7 1/2	371.5
8. Navío	16	42	53	7 1/2	8	5 1/3	1 7/9	7 3/4	3 1/4	35	8	444.5
9. Navío	17	44	56	8	8 1/2	5 2/3	1 8/9	8	4	37	8 1/2	530
10. Navío	18	46	59	8 1/2	9	6	2	8 3/4	4 1/4	37	9	624 1/8
11. Navío	19	48	61 1/2	9	9 1/2	6 1/3	2 1/9	9	4 1/2	39	9 1/2	721 3/4
12. Navío	20	49	63	9 1/2	10	6 2/3	2 2/9	9 1/2	4 1/2	39	10	821 7/8
13. Navío	21	51	66	10	10 1/2	7	2 1/3	10	5	41	10 1/2	946 1/2
14. Navío	22	53	68	10 1/2	11	7 1/3	2 4/9	10	5	41	11	1074 3/4

† *Toneladas*

Table 12. Deadrise (*astilla muerta*) and outward tilt of the futtocks at midships and tail frames (*joba*) as provided by the 1618 ordinances. F1 = Number of frames from the 2nd fore and aft of the mainframe, F2 = Number of frames from the 2nd fore of the mainframe, F3 = Number of frames the aft of the mainframe. All measurements in *codos*.

	Astilla	***Astilla* Main frame**	***Astilla* / F1**	**F1**	***Joba***	***Joba* / F2**	**F2**	***Joba* / F3**	**F3**
1. Navío	1/2	1/3	1/6	12	1/2	1/2	12	1/4	7
2. Navío	1/2	1/3	1/6	13	1/2	1/2	13	1/4	8
3. Navío	5/8	5/12	5/24	14	5/8	5/8	14	5/16	8
4. Navío	11/16	11/24	11/48	15	11/16	11/16	15	11/32	9
5. Navío	3/4	1/2	1/4	15	3/4	3/4	15	3/8	9
6. Navío	3/4	1/2	1/4	16	13/16	13/16	16	13/32	9
7. Navío	3/4	1/2	1/4	17	7/8	7/8	17	7/16	10
8. Navío	15/16	5/8	5/16	17	15/16	15/16	17	15/32	10
9. Navío	1	2/3	1/3	18	1	1	18	1/2	10
10. Navío	1 1/16	17/24	17/48	18	1 1/16	1 1/16	18	17/32	10
11. Navío	1 1/8	3/4	3/8	19	1 1/8	1 1/8	19	9/16	10
12. Navío	1 3/16	19/24	19/48	19	1 3/16	1 3/16	19	19/32	10
13. Navío	1 1/4	5/6	5/12	20	1 1/4	1 1/4	20	5/8	10

APPENDIX B

SELECTED TRANSCRIPTIONS

AGS, *Guerra y Marina,* leg. 640, n° 20

En el consejo se ha visto el papel incluso de Don Diego Brochero de Anaya y se ha parecido enviarlo a VMd. para que se sirva de mandarlo ver y acordar a VMd. que por ser de mucha consideración lo que contiene será muy del servicio de VMd. mandar nombrar personas que traten de lo que en el dicho papel se advierte y de los medios más propios para conseguir lo que conviene al servicio de VMd. e informen de lo que apuntaren para que VMd. mande tomar resolución en ello, en Valladolid a 3 de marzo de 1605.

AGS, *Guerra y Marina*, leg. 640, n° 21

En 3 de marzo de 1605

Consejo de guerra con el incluso papel de Don Diego Brochero.

Ordénese a los maestros y personas prácticas de fábricas de navíos que hubiere en Guipúzcoa, Vizcaya, Cuatro Villas, y Lisboa envíen su parecer, y véalos el Consejo y consúlteseme lo que en el pareciere, y entre tanto dejad en Don Brochero lo que se ofrece sobre armar, y favorecer la marinería para que se reduzca al punto que conviene.

Papel de D. Diego Brochero:

Opinión sin discuta es de muy grandes capitanes y de quien trata de razón de estado que el que fuere poderoso en la mar lo será en la tierra y con la experiencia que tengo de 38 años de navegación en las armadas de galeras y de alto bordo de VMd. y en las del turco el tiempo que fui esclavo he considerado en lo que consiste ser, VMd., señor de la mar con que se evitaran las desgracias que cada día suceden en las armadas de VMd.

Las fuerzas de la mar no consisten en entretener y sacar muchas galeras y navíos si salen mal, en orden con poca chusma y marineros ruin y poca jarcia y velas, artillería mal encabezada y pertrechada que cualquier temporal los derrota y desbarata y no hay duda que cuatro navíos bien en orden son de más sustancia y provecho que doce de la manera que ahora navegan tanto para pelear como para la navegación. Y ha llegado a tal extremo que de hambre, frío y por no curar los enfermos muere mucha gente y se desacreditan las armadas de V. Majestad.

Las naciones que más han estimado y honrado el oficio de marinero han sido ingleses y holandeses, y la gente más particular estima más ser capitanes de mar que de infantería, y se ha visto lo que han hecho con tan pocas fuerzas y ruin infantería, y los prósperos sucesos que han tenido sus armadas en las navegaciones tan extraordinarios que han hecho con tan pocos y pequeños navíos y poca gente que sólo se puede atribuir a la estimación que hacen del oficio de marinero y con tan poca costa suya han divertido los poderosos ejércitos y armadas de VMd. tan costosas.

Es muy conveniente que haya en estos reinos marineros naturales, que según los pocos que han quedado se puede decir no los hay y ni persona que tengan un poco de pundonor que lo quiera ser y más de las dos tercias partes de los que se levantan no lo son que con la codicia de las cinco pagas adelantadas asientan plazas de marineros sin serlo y recibiese por no haber otros y por sacar el numero de los que son menester la causa es porque entre la nación española es oficio muy bajo y las armadas de VMd. con los malos tratamientos los han casi acabado y otros han dejado este oficio viendo que no tienen ninguna ventaja ni remuneración ni esperanza de tenerla por sus servicios y no le hay en la guerra que tanto importe ser honrado como el de marinero que si la honra no le obliga a aventurar la vida en las ocasiones de la navegación y del pelear jamás será buen marinero quien no fuere honrado y si al soldado le estima y honra la república por aventurar la vida cuanto más de ordinario lo hace el marinero y ha llegado a tanto extremo que las veces que provee y capitanes para los galeones con ser oficio que debería ser de mucha estimación y honra rogaba con ellos a muchas personas muy ordinarias por no las hallar de la calidad que convenía y sin honrar este oficio no es posible ser, VMd., servido mi señor de la mar y de ordinario se verán más y mayores desgracias que hasta aquí.

Hállese la gente de mar muy desfavorecida por que no se acostumbra darles renta hábitos ventajas ni plazas muertas habiendo muchos que las merecen y que han peleado y se hallan estropeados en servicio de VMd., y que se de al soldado y no a ellos lo sienten mucho y para que VMd. vea cuanta falta de marineros hay en estos reinos los años de 1601, cuando para el viaje de Irlanda y el de 1602, que salí a correr la costa con hacerse muchas diligencias para juntar marineros no se hallaron estos reinos para armar cinco galeones y siete navíos de VMd., sino hiciera una cosa muy extraordinaria que fue sacar del puerto de Lisboa cuantos marinos que tuvieran los navíos particulares extranjeros y naturales con lo que se les hizo una muy grande injusticia y VMd. no será servido por ser gente forzada y no fuera posible salir del puerto y marineros forzados y extranjeros que no entendían a los oficiales ni los oficiales a ellos de deja ver que servicio hicieran en las ocasiones de la navegación y del pelear y cuando éstas se ofrecieran tenía más necesidad de guardarme de los enemigos que llevaba en la armada que de los de fuera porque debajo de nombre de alemanes, escoceses y franceses venían muchos ingleses y holandeses que por hacer una traición en la armada de VMd. se contentaban acabar ellos y en Irlanda se me huyeron muchos al enemigo y fueran más si no se pudiera el cuidado que en esto puse.

Mi proposición es que para ser VMd. el más poderoso rey del mundo y señor de la mar conviene honrar y premiar y pagar a la gente de mar y no será necesario acrecentar la paga del marinero ordinario que es bastante y honrando este oficio no será necesario sacar como ahora forzados los marineros y estos de poco provecho y para que los haya naturales y sean honrados como conviene cuando se me mandare diré lo que en esto se me ofrece.

Las fábricas de navíos que hasta aquí se han hecho por cuenta de VMd. no tienen la perfección y fortaleza que conviene por las varias opiniones de las personas a quien se han encargado y los particulares en las suyas visto el daño que reciben con los embargos y porque no se los embarguen para las armadas hacen sus navíos pesados, las cubiertas bajas y rifadas y con grañidísima desproporción para que no se pueda acomodar en ellos la artillería ni gente de guerra.

Si hoy quisiese VMd. juntar armada haciendo embargo general no se hallaran en toda España naos de particulares que puedan ser de provecho por estar hechas con la malicia que se ha dicho y como los que las fabrican no las navegan sino por granjería y por excusar la costa no les den la fortificación que conviene y así perderá cada año tanta gente, navíos y mercancías y no parezca costa labrar con la fortaleza que se dirá porque aun que lo sea y más de lo que ahora duran el doble y no se verán tantas perdidas.

Para evitar los daños referidos al remedio que conviene debería VMd. mandar juntar personas prácticas en la navegación y algunos maestros carpinteros para componer y ajustar las medidas, fábricas y fortalezas necesarias para que de una vez, quedase asentado con que cesaran las malicias y varias opiniones que hay en esto, haciendo las medidas y fortalezas desde un pequeño patache hasta un muy grande galeón mandando a los maestros mayores que las fábricas que hicieren de aquí en adelante por cuenta de VMd. y por la de particulares no sean de la orden que en esto se diere poniéndoles graves penas y haciéndose con estas medidas serán del mismo servicio los navíos de particulares que los galeones de VMd. y no será necesario más que embargarles y meterles la artillería y gente para formar una gruesa armada y para el trato de la mercancía serán mucho mejores.

De más del provecho que será esta junta para la fábrica y fortificación que se ha de hacer servirá de dar la orden que se ha de tener en el arqueamiento y formar un codo general porque en Vizcaya y el Andalucía se arquea de una manera y en Portugal de otra muy diferente y con esta junta quedara asentado de una vez el modo de fabricar y arquear y el codo uno con que se han de medir en todos los reinos de VMd. que de la manera que ahora se arquea arbitrando a unos se da más de lo que les toca y a otros menos.

Hay gran falta en estos reinos de jarcia y cáñamo y más que nunca y de esto ha sido la causa por que los proveedores y personas que por orden de VMd. han tenido a su cargo las fábricas han tomado por fuerza mucha cantidad a sus dueños sin pagársela y aún se debe mucha suma con que están perdidos y visto que todos los años se fabrica por cuenta de VMd. y que es fuerza tomarles la jarcia y cáñamo y que no se les paga han dejado de todo punto esta mercancía y los labradores de sembrar cáñamo que es digno de consideración y de remedio y esto se podrá hacer con dar orden que ningún ministro de VMd. pueda tomar ninguna jarcia ni cáñamo sin pagarlo primero y servirá de algún remedio por estar tan acabado este trato.

Deberíase mandar que ninguna clavazón de la que se gasta en las fábricas de navíos se hiciese ni labrase en martinete porque se tiene experiencia que no es buena correosa ni suave como la que se labra a fuerzas de hombres porque se rompen y saltan las cabezas con mucha facilidad sin poderse rebitar siendo fortaleza de tanta consideración la clavazón rebitada porque el martinete lo labra con la violencia del agua sin que el fierro tenga las caldas y temple que se requiere de más de que mucha gente pobre que solía sustentarse con este trabajo muere de hambre por no ser necesaria tanta con el martinete por hacer el agua la fuerza que solían hacer los hombres y esto mismo se debería en la fábrica de las ancoras que de algunos años a esta parte las sueldan en los martinetes y se quiebran y faltan con facilidad por las soldaduras la causa es como la fuerza del martinete las labra en tres o cuatro caladas no se pueden soldar como conviene y cuando las labran a brazos era necesario darles doce o quince caladas y de esta manera salía el fierro purificado y soldado como convenía y no se rompían con la facilidad que ahora y se deja ver del inconveniente que es si la armada tuviese necesidad de reparar sobre las ancoras una travesía no escaparía navío de más de la costa que hay y por las muchas que se pierden al zarparlas en los puertos.

Hay muy gran falta de artillería de mar como son medios cañones y cañones y artillería menuda si se fundiese de hierro con la perfección que la hacen en Inglaterra seria del mismo servicio y no de tanta costa y trayéndola de allá con la ocasión de las paces o comprándola de los navíos que vienen a estos reinos sería de menos costa y para el mismo efecto que las de bronce para las armadas.

Estos son los puntos más sustanciales que parece que VMd. mande poner el remedio necesario y aunque todos los son muchos el más importante será el de la junta de los maestros carpinteros y personas de mar para hacer y ajustar las medidas y fortalezas con que se deben fabricar y por obligar a particulares que hagan fábricas debería mandar VMd. que el que las hiciere con las trazas y medidas que esta junta les diere sean preferidas en la carga y descarga en todos los reinos de VMd. porque demás que la gente, mercancías y navíos navegaran con mayor seguridad serán de provecho para las armadas dándoles el emprestado del dinero que se ha acostumbrado por lo pasado.

AGS, *Guerra y Marina*, leg. 669, no 10

En 30 de enero de 1607

El consejo de guerra sobre socorrer a las personas que aquí se han juntado a tratar la forma de fabricar navíos.

Por hallarse en esta corte algunos hombres prácticos de fábricas y navegación de navíos de alto bordo se pregunto a Don Diego Brochero que otras personas de este ministerio se podía llamar para que juntos todos traten y confieran la forma que ha de ser unas medidas fijas para fabricar los navíos de VMd. así para los que han de servir en las armadas de la Carrera de Indias como en las del Mar Océano , porque de la variedad de opiniones que en esto ha habido, han resultado muy grandes inconvenientes haciendo los navíos de diferentes portes y traza de lo que son menester para una y otra navegación , y dice el dicho don diego que serán a propósito para esto el Capitán Agustín de Ojeda, y proveedor Juan de Pedroso que se hallan aquí presente, y que en Portugalete están los capitanes Martiarto y Pedro de Sancturse personas muy aprobadas en este ministerio y que así mismo lo son los maestros Martín de Sauto, Martín de Larraondo y Juan de Veas que están en Vizcaya y armada del mar océano y habiéndoles visto el consejo ha parecido consultar a VMd. por muy conveniente a su servicio que los dichos Agustín de Ojeda y Juan de Pedroso se detengan por ahora en esta corte, y que se llamen a las demás personas que don diego dice para que todos juntos y también Jácome Juan de Polo que se allá aquí traten y confieran la forma de hacer las dichas medidas y que para que puedan hacer su viaje se sirva VMd. de mandar proveer luego dinero para socorrerlos a cada cien ducados para el camino. VMd. proveerá lo que su real voluntad fuere en Madrid a 30 de enero de 1607.

También pareció la ultima junta de armadas que se llamasen para el dicho efecto a Valentín Temud que esta en Lisboa y a Juan de Uriarte, Juan de Axpe, Domingo de Varienga que se hayan en Vizcaya y son muy prácticos de este arte y adviértase también de esto a VMd. a que eligiendo los que fuere se llamen luego.

Firmado
Condestable
Conde de Olivares
Conde de Puñorrostro
Don B. de Velasco
Don Juan de Ibarra
Marqués de San Germán
Don Agustín Mejía
Juan Bautista de Tajis
Esteban de Ibarra

AGS, *Guerra y Marina*, leg. 669, n 206

En 13 de julio de 1607

El consejo de guerra sobre socorrer a las personas que aquí
se han juntado a tratar la forma de fabricar navíos.

Las personas que mando VMd. juntar en esta corte par conferir algunas cosas tocantes a la fábrica de navíos de estos reinos y hacer para este efecto unas medidas generales y tratar de remediar algunos abusos introducidos en el modo de arquear los navíos de particulares que sirven en las armadas de VMd. y otras cosas de este ministerio se hallan todavía aquí, porque después de haber hecho un papel en razón de esto conforme al parecer de todos ellos y de Don Diego Brochero y Esteban de Ibarra, que por acuerdo del consejo han asistido a esta junta se envió copia de él al Duque de Medina Sidonia y a Don Luis Fajardo para que la confiriesen con las personas más prácticas que se hallasen en el Andalucía y el Portugal y avisasen de lo que se les ofreciese sobre ello como lo han hecho y de lo que acá ha parecido sobre todo se dará cuenta a VMd., ahora piden licencia las dichas personas para irse a sus casas. Suplicando a VMd. se sirva de mandar socorrerles para su camino porque los doscientos que se dieron a cada uno de los más de ellos los han gastado en venir y aquí en las posadas desde cuatro meses que hace que salieron de sus casas donde han hecho y hacen mucha falta a sus haciendas, oficios y granjerías.

Y así han parecido al Consejo que pues vinieron llamados y a un negocio tan importante del servicio de VMd. se sirva de mandar socorrer a las nueve de estas dichas personas con cada cien ducados y al Capitán Agustín de Ojeda y al veedor Diego de Noja Castillo que son de más méritos e importancia en las cosas de este ministerio, con cuatrocientos ducados cada uno que todos montan mil setecientos ducados. Los cuales conviene dárselos luego aquí y a Diego de Noja no se le ha dado ninguna ayuda de costa y si VMd. fuere servido de aprobarla lo será de mandar al Duque de Lerma que firme el incluso billete para que el presidente de hacienda les haga pagar luego la dicha suma. VMd. proveerá lo que su real voluntad fuere.

En Madrid a 13 de julio de 1607

Firmado
El conde de Puñorrostro
Don B. de Velasco
Don Diego Brochero
Juan Bautista de Tajis
Esteban de Ibarra
Don A. de Soto Mayor

MNM, *Colección Vargas Ponce*, doc. 43, fol. 211-13

(Parecer de Juan Beltrán del Puerto sobre los inconvenientes de las medidas que se han dado para la construcción de Naos – Copia original en el Archivo de Guipúzcoa)

En 1610

Los inconvenientes que tienen las Naos que hacen y se hicieren en las medidas que su Majestad manda

1. Lo primero que siendo las Naos tan largas y con tan poco puntal serán tormentosas en la mar y cuando se encontrasen con algún temporal y por la gran fuerza del viento no pudieren traer velas se echaran al través y todos los golpes de la mar como es claro han de dar a las Naos del costado y por muy poco que ande alterado el mar los tales golpes le han de pasar del mar parte a otra y en la plaza de armas habría abundancia de agua y podría ser que alguna vez se viesen muy en aprieto los que navegan en ellas y echasen las artillería de arriba a la mar y las anclas y otras cosas que están a la mano.
2. Lo segundo, es que a nuestro parecer lo principal estas Naos no tienen bodega de consideración para llevar muchos mantenimientos para viajes largos hiendo de Armada y si van de mercante muy poca carga y en ninguna manera podrán jugar la artillería de entre las dos cubiertas que es lo esencial en las Naos de Armada a lo menos si hay un poco de marcha que muy poca bastara para estorbarlo porque no teniendo más puntal las portas de entre cubiertas estarán muy al ras del agua y este defecto tenían los galeones que traía a su cargo Don Luis Fernández de Córdoba excepto su capitana que tenía más puntal y lo mismo los que trae Don Antonio de Oquendo como fue en los galeones que ahora 26 años fabricó en Santander Cristóbal de Barros. Que por ser muy largas y razas y no poder jugar la artillería principal de entre las dos cubiertas hubieron de remediar dándoles más puntal, cerrando el castillete y el alcázar y hacerles contracostados para darles más manga.
3. Lo tercero, cuando estas Naos se concentrasen con el enemigo y se abordasen hace gran ventaja la Nao que tiene gran puntal al que tiene menos porque lo que esta más alto descubre mejor al que más bajo y así hace más daño la artillería, mosquetes y arcabuces que se tiran de alto y aunque no sea más de un codo de ventaja es mucho de manera que tenemos para nos que harán más efecto de la Nao que tiene más puntal cien arcabuceros que no ciento cincuenta de la que tiene menos.
4. Lo cuarto, que las Naos siendo muy largas y no teniendo al respecto puntal y manga no será buena Nao para barloventear con viento escaso porque con dificultad tomará por delante y cuando lo tomare tardará mucho y en esta tardanza pierde camino y cuando alguna vez con alguna mareta y con poco viento será dificultoso de hacerle arribar y muchas veces deberá de atener todo

> el aparejo digo velas que están en el Árbol Mayor y también la vela de la Mesana y haciendo todas estas diligencias alguna vez se ha visto no poder hacerle arribar y embestir con otra Nao siendo también la otra mala de arribar y en gran defecto para la Nao tener esta falta así por lo de arribada como de entrada y salida de puertos – Juan Beltrán del Puerto – Juan de Echavarri.

Debajo de otro mejor parecer digo que las Naos se habrían de fabricar de las medidas siguientes:
Cuando se quisiese fabricar un galeón de mil toneladas habría de tener cuarenta y cinco codos de quilla en derecho y de ganancia la tercia parte de ellos así de proa como de popa de manera que subiere sesenta codos de eslora y dieciocho codos y medio de manga o cuando mucho diecinueve codos menos un cuarto y de puntal hacer cinco quintos con esta manga y darle los tres de puntal a lo más ancho de la Nao y siendo el galeón grande habría de tener lo más ancho en la primera cubierta y a la segunda tres y media del puntal y su alcázar y castillete y que la cruz de popa fuere de nueve codos antes más que menos porque si peca de menos la Nao caerá para popa cuando haya alguna mareta y la lemera y los corredores habrían de estar muy alto de manera que fuera la mar brava no hiciese daño – digo esto por que se ha visto muchas veces y en hacer mayores Naos que estas medidas para el mar Poniente no se si advierta. Esta Nao será de novecientas toneladas cuando se fabricasen las Naos algo menores lo que fuese de 600 o de 700 – arqueándose como es costumbre habría de tener cuarenta y tres codos de quilla en derecho conforme se mide en Andalucía y Portugal y la tercia parte de cuarenta y dos añadir a la ganancia de proa y popa de manera que tuviese cincuenta y seis codos de eslora y de manga diecisiete codos y un tercio y de puntal haciéndose cinco quintos de esta manga dale los tres a lo más ancho y después añadir tres codos y un cuarto para la puente de arriba y su alcázar y castillete.

Para cuatrocientas toneladas conforme al arqueamiento de treinta y siete codos de quilla midiéndose como arriba digo y añadiendo la tercera parte de treinta y siete para la ganancia de proa y popa de manera que de eslora tenga diez codos (error en el manuscrito, la eslora seria de 49 ⅓ codos) y de manga quince codos y cuarto y cuando mucho quince y medio y de puntal habiéndose cinco quintos de la manga darle tres de manera que viene a ser nueve codos largos de puntal a lo más ancho y esto ha de tener más arriba de la cubierta medio codo y basta que tenga tres codos de altura de una cubierta a otra o cuando mucho tres y cuarto de manera que todas las Naos han de tener que sean mayores o menores tres veces más que la manga la eslora y cuando mucho añadiendo más cuatro codos y si la Nao es grande cinco y de puntal hacer cinco quintos la manga y darle tres quintos y estas medidas para conformidad sirven para cualquier nao de guerra o de mercante y las Naos de cuatrocientas y quinientas toneladas son de más servicio para andar y navegar y andan más seguras en entradas de puertos y para las Naos de estas medidas se hallan árboles donde quiera y no mayores.
Juan de Beltrán del Puerto
Juan de Echavarri

Original en el archivo de Guipúzcoa

AGS, *Guerra y Marina*, leg. 776

En 8 de octubre 1612

Decreto del consejo de Guerra sobre lo inclusos papeles que trajo a el Sr. Diego Brochero de Anaya tocantes a la nueva ordenanza de arqueamiento de navíos.

Por orden de VMd. y del Consejo de Guerra se me mandó que con asistencia del Proveedor Don Joan de Pedroso, el Doctor Arias de Loyola, el Doctor Cedillo, cosmógrafo y catedrático de matemáticas en esta corte, el licenciado Antonio Moreno, cosmógrafo mayor de la Contratación de Sevilla, Don Alfonso Flores y Juan de Veas, Maestro mayor de fábrica de naos, se confiere el modo de medir y arquear las naos que se reciben a sueldo para servir en las Armadas y flotas habiéndose mirado con mucha especulación y cuidado y advirtiendo los errores y daños que ha habido por lo pasado que por ser materia de tanta importancia, tan dificultosa de ajustar y componer se ha ocupado muchos días y con mucho estudio y experiencias se ha resuelto y asentado la instrucción que será con este papel en el que para que mejor se entienda en lo que se ha constituido los daños y cuan vistos y bien advertidos y reparados van, se hacen las advertencias siguientes:

- Antiguamente se acostumbraba en Castilla medir las naos con unos aros de pipa de fierro como ahora se hace en Portugal y de aquí tiene el nombre de arquear y porque esta medida es incierta se dejo de hacer y se introdujo el medir con codo como ahora, no midiendo más que la manga, puntal y eslora sin medir el plan y quilla que son las medidas más importantes y sin ellas es imposible ajustar la cuenta.
  Por estas medidas se hacía la cuenta guardando la regla que llaman de Tres, Dos, As, que la manga dos veces el puntal y tres mangas la eslora, y para las naos que salían de esta proporción en el modo de hacer cuenta había regla en que se recompensaba y llegaba más a la verdad que la que ahora se guarda aunque no cierta por faltarle las dos medidas que se dicen ni en las fábricas había las desordenes y malicias que en estos tiempos y así se hacía la cuenta con menor error aunque no ajustadas.

- Con el tiempo se fue mudando el modo de fabricar reduciéndose a muy mal estado y olvidando el hacer esta cuenta y creciendo y disminuyendo el grandor del codo de manera que para evitar la confusión y engaño que en esto había el Rey Ntro. Señor que haya Gloria por instrucción que se hizo en 20 de Agosto del año 1590 mando señalar el tamaño del codo con que se había de medir en todas partes y dar la orden como se habían de tomar las medidas de la manga, puntal y eslora sin declarar como se había de hacer la cuenta mandando que las medidas se enviasen al Consejo de Guerra para que de él se remitiesen a las personas que los había de hacer, nombrase para esto a Cristóbal de Barros con la superintendencia de las fábricas y plantíos y porque luego se hicieron Proveedor de las Armadas de la Carrera de Indias muy pocos días se observó este modo de remitir las medidas al Consejo de Guerra se ha seguido que en cada parte donde se tomaban las medidas hacían la cuenta y como no tenían noticia del modo como se habían de hacer que es el que queda dicho que habían de recompensar las desigualdades hacíanla sin recompensar nada por donde vino a ser mayor el daño y ser muy grande el engaño contra la Hacienda de VMd.. habiendo diferentes medidas con muy grandes crecimientos del puntal ayudando a estos y error ser mayor los defectos de la mala fábrica particularmente en la mucha falta de plan y demasiados lanzamientos para cuyo conocimiento no había medida ni regla y es así sin duda que iba de engaño contra las regla as, dos, tres lo ordinario el quinto y muchas naos el cuarto y en otras más. Por haberse dado cuenta a VMd. de estos engaños en el mal modo de medidas y hacer la cuenta el año pasado de 1607 mando VMd. algunos fabricadores y personas prácticas de la mar y navegación para dar nueva orden así en el modo de fabricar como en el medir y hacer la cuenta de las medidas, y aunque hizo instrucción de ello por no haber en estas personas bastante ciencia y noticia de lo que consistía el error de las medidas no se salió con la justificación que se deseaba por consistir la certeza de estas medidas en matemática y geometría no se acertó lo que convenía.

– Ahora con la asistencia de Juan de Pozo que fue el que dio noticia del engaño que había en esto ya hecho instancia para que se confiera y enmiende y la mucha ciencia del Doctor Arias que como tal ha sido quien ha hallado la regla y nuevo modo que se ha de hacer la cuenta y Juan de Veas como el más práctico y mayor fabricador que hay en España y la especulación y conferencia de los demás es certísimo que el modo de medir y hacer la cuenta que se ha hallado y se ha puesto en la instrucción es el más ajustado y verdadero que se puede hallar, trabajado, mirado y experimentado como se puede colegir del mucho tiempo que se ha ocupado en ello y se podrá ver en un particular tratado que sobre ello hace el Doctor Arias en que pone todas las consideraciones y experiencias que para cada cosa ha tenido, y por esto se debe mandar guardar esta instrucción con mucha seguridad de que las medidas y cuenta son las que convienen y las más ciertas y ajustadas que pueden ser como se ha experimentado en las medidas de los navíos que para este efecto se han hecho en esta corte de diferentes formas y grúas en que se ha hecho la experiencia y comprobado ser verdadera.

– Como se verá en la instrucción no se muda el tamaño del codo ni se alteran las tres medidas que antes se tomaban, sólo se da punto cierto donde se han de tomar y se añaden las del plan y la quilla que es lo más esencial e importante y que hasta aquí no se ha medido, darse regla para hacer dimensión de lo que faltaren a la buen proporción y medida que de más de ser esta cuenta ajustada y cierta para todo género de navíos por diferentes que sean las fábricas de ellos viene a ser tal proporción con los que se fabricaron conforme a la nueva ordenanza que se hace del modo de fabricar que tienen las mismas toneladas que se les diesen por medida y cuenta que se reforma con que queda probado ser la cuenta la cierta por lo que se les quitare a los demás naos será los que les faltara por la mala fábrica y dejaran de cargar y llevaran hasta aquí con mala conciencia no siendo capaces de aquel porte y carga.

- Por esta razón se obliga que de aquí en adelante las fabricadores hagan sus naos en buena proporción y medidas sin los engaños y desigualdades que ahora se hacen pues todo lo que excedieren lo perderán en el valor de la medida que es la pena que han de tener más los que se ponen en la instrucción y les a de obligar a hacer las fábricas con la perfección que conviene y se manda.

- La causa principal en que ha consistido la variación, abusos y engaños en las medidas ha sido por no haber habido persona que residiendo en esta corte como se hacía antiguamente sea superintendente de estas medidas y fábricas para hacer estas cuentas y será de tanta importancia como lo es el guardar las instrucciones que sobre ello se hacen pues ha de ser el que ha de reforzar los excesos que se hicieren y ha de tener un libro en el que ha de asentar todas las naos que se fueren fabricando de nuevo con las medidas que cada una tuviere quedara obligado el dueño de la tal nao a traérsela o enviársela por testimonio de la Justicia del lugar donde se fabricare y así mismo la enviara por su parte al superintendente de fábricas y plantíos del distrito donde se fabricare para que la una confronte con la otra y se ha de mandar a los proveedores y demás ministros de Armadas que todos los naos que midieren y recibieren al sueldo luego como tomaron las medidas envíen un tanto de ellas y de la cuenta que hicieren al tal superintendente para que vean si van ajustadas y se guarde la instrucción con que se excusara el pervertirlos como por lo pasado y los fraudes que podría haber dando cuenta el superintendente al Consejo de las desórdenes que hubiere para que se remediare y castigue.

En Madrid a 8 de octubre de 1612

El Prior de Ibernia
Diego Brochero

AGS, *Guerra y Marina*, leg. 3146

En 19 de noviembre de 1612

El Consejo de Guerra con las inclusas ordenanzas sobre la nueva forma de fabricar navíos en estos reinos.

(para firmar estas ordenanzas habían de venir con ellas las que antes firmaron y ahora se hallan defectuosas y así se junten y se me avise si sobre estas últimas se ha pedido parecer a Don Luis Fajardo y también al Duque de Medina Sidonia)

Van aquí las ordenanzas primeras como VMd. lo manda y no se ha pedido parecer sobre las últimas a Don Luis Fajardo, ni la Duque de Medina Sidonia. En 10 de diciembre de 1612

En primero de julio de este año se sirvió VMd. de firmar unas ordenanzas sobre la fábrica de navíos de VMd. y de particulares en estos reinos porque las otras hechas el año de 1607 para el mismo efecto, y para el arqueamiento o medida de los navíos que sirvieren en las armadas de VMd. a sueldo fue descubriendo la experiencia algunos defectos dignos de remedios y de que resultaran inconvenientes en daño del servicio y hacienda de VMd. y perjuicio de los naturales como se presento a VMd. por consulta del 6 de junio de este año, enviándoselas a firmar, y porque antes de publicar estas ordenanzas, las volvieron a ver Don D. Brochero y otras personas peritas de este ministerio que han hallado algunas cosas de importancia que reformar y ofrecidoseles otras para añadir (lo cual se ha hecho con particular cuidado) ha parecido enviar a VMd.. las inclusas ordenanzas, sirviéndose de firmarlas, se publicaran y usará de ellas, y el Consejo estará a la mira de si el tiempo y la experiencia mostraren alguna imperfección o inconveniente para que se procure remediar, como cosa que tanto importa, y cuanto al arqueamiento y forma de medir navíos que sirvieran a sueldo, se han hecho otras ordenanzas que se enviaron a VMd. con consulta de 7 de este presente mes.

VMd. mandará proveer lo que fuere su real voluntad, en Madrid a 19 de noviembre de 1612.

AGS, Guerra y Marina, leg 3146

En 22 de mayo de 1613

El Consejo de Guerra, con la inclusa consulta y ordenanzas nuevas para fabricar navíos en estos reinos

(Vuelven firmadas)

A la inclusa consulta de este Consejo fecha a 19 de diciembre del año próximo de 1612 sobre las ordenanzas que con ella se enviaron a firmar de VMd. para la nueva forma de fábricas de navíos se sirvió VMd. de responder y mandar que se pidiese parecer al Duque de Medina Sidonia y a Don Luis Fajardo, lo cual se hizo así. Y acordó el Consejo que lo que respondieron lo viese Don Diego Brochero y dijese en el lo que ofreciese en la materia y en cumplimiento de ello refiere lo siguiente:

Que el Duque de Medina Sidonia dice que las medidas están bien consideradas y acabadas y sólo le parece que se da mucha quilla y bastará dar dos codos y medio de quilla por uno de manga y que entiende que ha de haber falta en la ejecución de las ordenanzas no obstante su bondad por el inconveniente que resulta de que los visitadores de la Carrera de las Indias no son prácticos de la navegación. Y que si no se informan de otros no acertarán al dar el parecer que conviene. Y que no es a propósito para la navegación y Carrera de Indias que los navíos sean de más porte que el que disponen las dichas ordenanzas. Y suplica a VMd. que para que se ejecuten puntualmente se den los oficios de Visitadores de las flotas de Indias a personas que tengan la experiencia y práctica necesaria.

Que Don Luis Fajardo se conforma en todo con las dichas ordenanzas por parecerle bien acordado y dispuesto lo que contienen. Reparando solamente en que se podría quitar un codo de la quilla si bien considera que no por largos son los navíos malos.

Don Diego Brochero se afirmó en que le parece que no hay que añadir ni quitar en las dichas ordenanzas pues se hicieron con acuerdo de tantas personas prácticas de la navegación y la fábrica de navíos en el que pusieron el estudio y trabajo que es notorio en el entretanto que la experiencia de la navegación no descubriere nuevas causas para alterarlas.

Al Consejo a parecido volver a VMd. la dicha consulta y con ellas las ordenanzas para que si fuere servido de aprobarlas las firme y se comience luego a usar de ellas porque hay muchas personas particulares que esperan esta resolución para fabricar navíos y se les sigue daño de la dilación.

VMd. proveerá lo que su Real Voluntad fuere. En Madrid a 22 de mayo de 1613.

VITA

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