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Sizes and Configurations of Spanish Ships in the Age of Discovery*

Carla Rahn Phillips
University of Minnesota
Minneapolis/St. Paul, Minnesota

ABSTRACT

What little we know about ship dimensions during the Age of Discovery is speculative at best. The documentary evidence has not yet been studied in detail, and there are very few physical remains to guide us. As nautical archeology discovers more shipwrecks, we can look forward to a vast improvement in this state of affairs. Until then, documentary evidence about ideal and real ships for Mediterranean, Atlantic, and Pacific waters can serve a useful purpose, providing us with a range of common ship dimensions.

This paper discusses the meaning of the five measurements used to define Spanish ships in the Columbian period and thereafter. It then analyzes the common formulas used to calculate ship tonnages based on those five measurements. Tables listing more than 100 real and ideal ships accompany the paper. They include small vessels as well as large warships and merchantmen. The best estimates we have for Columbus's ships are examined in light of the previous discussion of measurements and tonnages. In conclusion, I develop a new set of estimates for Columbus's ships and a method for estimating the measurements of other historical ships.

INTRODUCTION

As the quincentenary of the first voyage of Christopher Columbus approaches, we can hope for an outpouring of scholarly research on many topics surrounding the man himself and the world in which he lived. High on the list of topics are the ships that carried Columbus and his men on that first voyage. Those ships still capture our imagination, symbolizing the breathtaking audacity of the voyage, however we define its purpose and its results. They also represent something much broader, a nexus of the technological development of the period. I would hope, as research for the quincentenary proceeds, that the study of Columbus's ships keep this broader context in mind, because in understanding his world as a whole, we can best understand Columbus and his place in it.

We know very little about Columbus's ships, despite the lively interest of scholars over the centuries. For that matter, we know very little about any European ships before the late sixteenth century. Sketches and plans are exceedingly rare, as is the evidence about shipwrecks from nautical archeology. For the moment, our best sources are documents describing the ships and pictorial evidence of varying plausibility. Happily, the documentary evidence is mounting steadily, as scholars discover the astounding wealth and variety of information in the archives in Seville, Simancas, Madrid, and port cities around the Iberian Peninsula. That makes it possible to develop a range of ship sizes and configurations that were commonly found in Spain.

In the course of other research, I have collected data on numerous ships that were proposed or actually built in the fifteenth, sixteenth, and seventeenth centuries. Mine is not a scientific sample, by any means. It is simply a collection of ships that left fairly detailed records in the documents I was consulting. Nonetheless, they exhibit surprising similarities, encouraging the hope that they represent the range of sailing ships in Columbus's time and thereafter.

First I will deal with the measurement conventions used for Spanish ships. Then I will discuss the official rules for figuring tonnages based on those measurements. Finally, I will examine the data I have collected for more than 100 ships, both ideal and real, including the best estimates we have for Columbus's ships.

MEASUREMENT CONVENTIONS

Among those who study sixteenth and seventeenth century maritime history, it is generally known that the Spanish used five principal measures to define their ships: beam, keel, length, floor, and depth. Unfortunately, it would appear that we have missed important variations in the meaning of these terms, particularly depth. The problem becomes clear by examining the definitions of each of the terms and by taking a fresh look at one of the most famous early nautical treatises, the *Instrucción náutica* of Diego García de Palacio.

Official Spanish regulations for calculating ship tonnages (by the process called *arqueamiento*) ordinarily specified where to take the measures. For example, the regulations published in 1590 assumed that the decks had not yet been planked, and established procedures for measuring with lines stretched from point to point inside the hull.[1] Rejecting this approach, the 1607 regulations called for taking measurements at the lower deck, "and not in the air as heretofore has been done."[2] When historical documents or nautical treatises provide us with some or all of the measures, it is an easy matter to calculate ratios and compare them with similar ratios for other ships, both ideal and real. First, however, we must know exactly what was meant by the measures, and which set of regulations governed them.

The beam (*manga*), defined as the widest point of the hull, was enclosed by the master ribs. At times the beam would correspond to the breadth at the lower deck. At other times it would be situated above or below the lower deck, though its official measurement would normally be taken on the deck itself. Apart from that, the definition of the beam was straightforward, with more or less exact counterparts in other nations. (See Figures 1 and 2 for ship diagrams.)

The keel (*quilla*) or spine of the ship included only the straight portion of the timbers forming it, measured from the outside. The sloping stempost (*roda*) and sternpost (*codaste*) were not included. The definition of the keel did not change over time, and, like the beam, it had more or less exact equivalents in other nations.

Length (*esloria*) was another matter. In Spanish usage, the length of the ship was generally measured on the lower deck, from stem to stern. The length and the keel had a relationship customarily defined in two parts. The so-called *lanzamiento a proa* was the forward extension of the lower deck beyond the keel. The *lanzamiento a popa* was the aft extension. Adding both *lanzamientos* to the keel gave the length or *esloria*. For Spanish galleons of the early seventeenth century, the forward extension was generally about double the aft extension, giving the ships a pronounced forward rake.[3] There is no English equivalent of the *esloria*, as those in the field know well.[4] The English "length overall," as described in a document from 1637, included the distance from the fore-end of the beakhead to the aft end of the stern,[5] a considerably longer measure than the *esloria*. Continental nations seem to have used a measure of length closer to Spanish than to English usage,[6] and any comparisons of ship lengths and the ratios of length to beam must take these varying definitions into account.

The floor (*plan*) in Spanish usage was measured at the bottom curves of the master ribs, as if the distance between them were flat. Like the other measures, the floor was best measured before the ship was finished. Once planking was in place above the bilge, it was much more difficult to gauge precisely.

The definitions of these four measures changed little over the centuries, though the formulas for deriving tonnage from them were revised several times.[7] Thus, historians studying the evolution of ship design in the sixteenth and seventeenth centuries can confidently compare ratios of keel to beam or length to beam from one period to another.

Quite a different conclusion emerges from a close examination of the fifth measure — the depth (*puntal*) — and what it meant to Diego García de Palacio and others. García de Palacio published the first full-blown treatise on shipbuilding — his *Instrucción náutica* — in Mexico City in 1587.[8] The Portuguese manuscript of Fernando de Oliveira, evidently written in about 1565, was not published until the late nineteenth century,[9] and the 1575 manuscript of Juan Escalante de Mendoza[10] was far less detailed about ships than García's analysis. The *Instrucción náutica* remains an invaluable

guide to a wide range of topics in early modern maritime history, from the design of ships to the duties of officers and crew members.

In the course of his analysis, García shared his notions of ideal ship proportions. Dealing with a merchant vessel (*nao*) of 400 *toneladas*,[11] he presented four of the five principal measures in turn, accompanying his text with illustrations drawn to scale. (See Figures 1 and 2.) For a beam of 16 Spanish *codos* (each one 22 inches or about 565 mm), the ship should have a keel of 34 *codos*, a length of 51.33 *codos*, and a depth of 11.5 *codos*.[12] This meant the ship would have had a keel to beam ratio of 2.13, a length to beam ratio of 3.21, and a depth to beam ratio of 0.72. The first two ratios follow closely the traditional proportions for merchant shipping in the Mediterranean of "as, dos, tres," in which every unit of beam was matched by two units of keel and three units of length on deck.[13] Such typical merchant "round" ships contrasted quite sharply with the other famous Mediterranean vessel — the galley — which could have length to beam ratios as high as 6 or 8 to one.[14]

The third ratio derived from García's figures, that of depth to beam (0.72 to one), supports the general assumption that merchant ships in the late sixteenth century were quite deep in the hold, much deeper than Spanish ships would be just a few decades later. If this were true, a major revolution in design must have occurred between the time García wrote and the appearance of the first official regulations for Indies ships in 1607, which called for ratios of depth to beam of about 0.54 to 1. (See Table 1.) Instead, we are dealing with a discrepancy in the definition of depth, not with a revolution in design.

García stated explicitly how he had derived his figure for depth. Starting from the floor, he divided the hold into three parts. The first division ended with unplanked braces called empty bows, placed at 4.5 *codos* above the floor, equivalent to the height of three pipes (large barrels) of wine. The second division ended with the lower deck (*primera cubierta*), placed 3 *codos* above the empty bows, equivalent to the height of two pipes of wine. The third division ended with the upper deck or bridge (*puente*), 3 *codos* above the lower deck. The total of 10.5 *codos* rose to 11.5 with the thickness of the braces and planking included. Ships that carried a grating (*jareta*) above the bridge to enclose additional deck space would add another 3 *codos* to the depth.

It is obvious from this that García included in his depth measurement all the enclosed area of the hull. Just over a decade earlier, in contrast, Escalante de Mendoza had defined the depth as the distance between the floor above the keel and the first fixed deck.[15] Though Escalante did not provide a figure for depth in the ideal ship mentioned in his treatise, there is no question that his definition would be the one preferred in later Spanish usage. The 1590 regulations called for measuring the depth at about the point where the first deck would be placed, and the 1607 rules explicitly defined the depth as the distance from the floor to the top of the first deck. All of the later rules for ship measurement would follow this definition of *puntal* as the depth in the hold alone.

Some shipbuilders in the late sixteenth century may have used the inclusive definition of depth favored by García, rather than the more limited depth in the hold of Escalante. Contracts for 25 Basque *naos* built from 1545 to 1611 included specifications for the depth at the second deck, as well as at the location of the maximum breadth (beam). In many cases, however, the depth at the first deck was not even mentioned. Depth to beam ratios figured at the maximum beam ranged from 0.66 to 0.73.[16] Where the data are sufficiently complete to figure depth at the first deck, the ratios are much lower. Only seven of the *naos* had complete data. I include them in Table 2, listing their depth at the first deck. Another 12 ships that entered Spanish service ca. 1580, built by Neapolitans, Venetians, and Ragusans, show depth to beam ratios ranging from 0.52 to 0.73.[17] It is possible that more than one definition of depth was used in their measurement as well.

Without knowing the bases for individual ship measurements, we can do no more than recognize possible discrepancies in their figures for depth. We can, however, correct the figures commonly attributed to García de Palacio. In order to bring García's ideal merchant ship into line with other treatises and with official regulations, we must use his figures for depth from the floor to the top of the first deck only, rather than the full amount that he called the depth. This means 4.5 *codos*, plus 3 *codos* for the space between the floor and the deck, plus an estimate for the planking. I propose using the figure 7.75 *codos* in all. This reduces the ratio of depth to beam in García's ship from 0.72 to 0.48. It also has the merit of reconciling García's measurements with the 400 *toneladas* he attributed to the ship.[18] (See Table 1.)

The corrected depth of García's ideal merchant ship comes quite close to the figures proposed in official regulations for the Indies trade in 1607, 1613, and 1618, in which the depth to beam ratios ranged from 0.46 to 0.55 for variously sized ships. (See Table 1.) Where the government's regulations and later treatises would diverge greatly from García's *Instrucción* was in increasing the ratio of keel to beam. The seventeenth century would continue this trend, both public and private, toward lengthening the hull in all types of ships. That much we have known for some time. What is new in taking a fresh look at García's treatise is that his ideal merchant ship was not particularly deep in the hold. Nor, if we accept that the Basque *naos* and some of the Mediterranean ships mentioned above used García's definition of depth, were they particularly deep in the hold, either. In light of this, we must revise some of our notions about the configurations of ships used in sixteenth century Spain and its Indies trade. The traditional merchant "round" ship was not quite as round as we thought.

TONNAGE CALCULATIONS

There has been considerable controversy over the definition of the Spanish *tonelada*, but, according to the official regulations in 1590, it was worth

8 cubic *codos* in capacity, equal to what is sometimes called the *tonel macho* of Vizcaya, and to the old French *tonneau de mer*.[19] Thus, in the formulas developed to calculate ship tonnage, a figure for cubic *codos* was divided by 8 to yield *toneladas*.

The *tonel macho*, which could be called a ship *tonelada*, was 1.2 times larger than the merchandise *tonelada* used for the Indies trade in Seville, so that 12 merchandise *toneladas* equalled 10 ship *toneladas*. Many historians have assumed that contemporary writers such as Escalante and García used the merchandise *tonelada*, whether describing ships in general or their merchandise capacity. I would argue that this is mistaken. García clearly had the larger ship *tonelada* in mind in describing ships. Escalante seems to have used the ship *tonelada* as well, when referring generally to ships. The passage in his *Itinerario* has given rise to much confusion, as he mentions both sorts of *tonelada* together, but he differentiates their use for ships and for merchandise capacity.[20] Tonnage measures had their roots in the wine trade, and the ability of a ship to carry a certain number of wine barrels of more or less known weight. As it evolved, Spanish tonnage continued to refer to both volume and weight, as the formulas to calculate it demonstrate.

Two formulas for calculating tonnage generally held sway in Spain in the sixteenth and seventeenth centuries, and perhaps earlier as well. The version for merchant ships can be expressed as (depth times beam) divided by 2; the result times length on deck; the product divided by 8. For warships, the formula was (depth times beam) divided by 2; the result times length on deck; minus 5%; the result divided by 8; plus 20%. All measurements were in linear *codos* equal to 22 inches or 565 mm, and the final figure for both formulas was in *toneladas*. When the same ship was gauged by both formulas, it measured about 14% larger as a warship than as a merchant ship. This was not the same as the difference between the ship *tonelada* and the merchandise *tonelada*, however. The version of the formula for merchant ships (Method 1 on Tables 1 and 2) was already in *toneles machos* or ship *toneladas*. The version for warships (Method 2 on Tables 1 and 2) resulted in an additional 14%.

Both formulas attempted to solve the problem of finding a cubic measurement for something other than a cube. The first part of each formula calculated the square measure of a cross section of the ship. Beginning with the product of the depth times the beam, it halved the result to account for the shape of the hull, which narrowed progressively fore and aft of the master ribs along the length. Because warships were thought to lose more capacity than merchant ships, from more sharply narrowing hulls and more internal bracing, an additional 5% was subtracted from the square measure of their cross-sections. A fraction could also be subtracted from certain merchant ships, if their shape justified it. The square measure for the average cross section was then multiplied by the length on the first deck, giving a total measure for the hold in cubic *codos*, which was divided by 8 to yield *toneladas*.

The Spanish government instituted a new set of formulas in 1613, rescinded it in 1618, and reinstituted it in 1633. The calculations varied depending on whether the floor was equal to, greater than, or less than half the beam. The simplest version, which could be applied regardless of the ratio of floor to beam, can be expressed as: .5 depth, times (.75 beam + .5 floor), times .5 (length + keel); the result divided by 8. This gave a tonnage about 12-14% smaller than the standard method for merchant ships just mentioned, which would have favored the crown in renting ships by the *tonelada*. In other words, it marked a return to the merchandise *tonelada*. Though the new set of formulas had the merit of trying to account more accurately for the capacity of the hull, it took quite a while to be widely used. Tonnages given in the tables appended to this paper all seem to have been calculated from the earlier formulas, even the government regulations issued after the new formulas became official. Eventually, however, the new formulas would prevail.[21]

ANALYSIS OF TABLES

Keeping in mind the customary meanings of ship measurements and the methods used to calculate tonnage, we can turn to the ideal and real ships listed in Tables 1, 2, and 3. For all of the ships, the tables include their measurements in *codos*, a calculation of their tonnages as merchant (Method 1) or military (Method 2) vessels, and a set of ratios defining their overall configurations. In proposing ideal ship proportions in 1575, Juan Escalante de Mendoza started with the proportions of keel, length, and beam and derived measures for variously sized ships from those proportions.[22] Other authors began with proportions, then adjusted them incrementally according to the size of the ship. All of the ideal ship proportions presented in table 1 followed one of these two approaches. The author of the "Diálogo" written ca. 1635, for example, seems to have begun with firm ratios in mind for keel to beam and floor to beam, varying the other measures for different sized ships.

The depth measure differentiates the treatises and government regulations in Table 1 from one another. Once we have adjusted García's measures to conform to the rest, all used a depth measure for the hold alone. Everyone dealing with the problem of ideal ship proportions was well aware that a ship would vary in speed and handling, depending upon the relationship of depth to beam. Tomé Cano (1611) and the author of the "Diálogo" (ca. 1635) both favored greater depth in the hold than government regulations called for. This was due in part to the larger capacity for trade goods that a deeper hold would provide, but the authors also argued that ships would handle better with a deeper hold.[23] The government regulations of 1607 evidently shared that opinion, but later versions would require a depth equal to less than half the beam.

Tonnages calculated according to Methods 1 and 2 provide useful comparisons with tonnage figures given in the source. García (1587) was describing merchant ships, and the close correspondence of his tonnage figures and the results calculated according to Method 1 confirms this. Equally clearly, the tonnages given in the 1607 regulations had warships in mind, as many of their critics claimed. Cano applied both methods to the same ideal ship, which was common practice in reality as well, when merchant ships sailed for the crown. The 1618 regulations seem to have used a modified version of Method 2, perhaps subtracting more than the customary 5% from the square measure of the average cross section.

The ideal ships listed in Table 1 may or may not have had counterparts in the real world. The ships listed in Tables 2 and 3, on the other hand, actually existed, though we do not know all of the five principal measures for some of them. Looking over both lists, from the early fifteenth to the late seventeenth century, there are striking similarities in the shapes of the larger ships, whether they sailed as merchantmen or as warships. Over time, there was a lengthening of the keel to beam ratio, measureable from about the 1570s to the 1670s. A Basque *nao* in 1577 had a ratio of 1.94, and a galleon built in Basoanaga in the Basque region in 1668 had a ratio of 2.86. We might assume that warships were always sleeker than ordinary merchant *naos*, but the documents do not support such an assumption. The list of 21 ships being repaired in Seville in 1625 had an average keel to beam ratio higher than that of six galleons built for the crown for military duty and measured in 1627.

The ratio of length to beam did not show any clear trend. Though the Basoanaga galleon of 1668 was longer on deck than all but a few of the other ships on the list, there was not a clear trend toward a general lengthening over time. The 12 ships built by Venetians, Neapolitans, and Ragusans, measured in 1580 for Spanish service, showed higher length to beam ratios than many later ships, including the warships measured in 1603 and 1627. The 12 foreign ships had shorter keel to beam ratios than those same ships, however, and a narrower floor, suggesting design differences between Spain and areas farther east in the Mediterranean. Even omitting them from consideration, there was no clear trend in the length to beam ratio.

It is difficult to compare the total tonnages and cargo space among all the ships listed, due to possible variations in the definition of depth, as discussed above. I suspect that any ship with a depth to beam ratio much over 0.60 included all the space in the hull as the depth. We must be very careful, therefore, not to assume that ships are directly comparable, unless we can know, or infer, the basis of their measurements.

The persons figuring tonnages in the sources used fractions, not decimals, and they had some discretion in deciding whether or not to apply the full formula. That explains a certain variation between my calculations and the figures given in the sources. Most of the given figures fall much closer

to one method than the other, however. Bertendona's warships were undoubtedly measured by Method 2 in 1603; the 21 ships listed in Seville in 1625 were undoubtedly measured by Method 1, as merchant ships. How the source measured it is not a foolproof guide to a ship's function, however. The six galleons measured in 1627, though warships, had their tonnage calculated by the formula for merchant ships.

The foreign ships measured in 1580 raise different but related questions. Some of the figures given in the source are quite close to either Method 1 or 2. Others diverge from the nearest calculation by greater or lesser amounts (all but one positive), ranging from - 3.7% to + 24.8%. A certain tendency of given tonnages to cluster at even 100s suggests that some of the ships were roughly estimated rather than calculated. There is no consistency in the variations, so it is unlikely that a different formula was being used. The problem is the same with the Italian ships listed in Table 3, for which I converted Venetian feet to *codos* and Venetian *botte* to *toneladas*.[24] If my conversions are correct, the *nave* listed for 1420 fits plausibly within the same range as the Spanish ships. The *nave* listed for 1608 does not. It seems to have far too little depth and length to supply the tonnage given in the source. Similar doubts apply to the Venetian *naves* listed for 1550, 1591, 1597, and 1599, though there is not enough information to know for certain what caused the variations.

Used with caution, the formulas I have called Method 1 and 2 can serve as preliminary tests of the accuracy of a set of ship measures, if we assume that they can apply not only to Spanish ships, but to others as well. Calculated from trustworthy figures for known ships, they can also provide clues for estimating the configurations of unknown ships. For example, *La Couronne*, a French warship in service in 1636, was considered enormous, widely reported to have a capacity of 2,000 *toneladas*.[25] One Spanish naval commander remarked that a ship of such size was "never before seen on the sea."[26] Unfortunately, we lack precise measurements for *La Couronne*, and the estimates commonly accepted[27] seem too small to describe a ship of such magnitude. Comparing those figures with the proportions in contemporary Spanish warships suggests that *La Couronne* should be given more depth. As an experiment, if we take *La Couronne's* beam and assign other measurements according to Spanish warship proportions, its estimated tonnage is much more plausible. In fact, it is very close to the 2,000 *toneladas* that justified the vessel's reputation.

A similar process can be applied to estimate much earlier ships, comparing theoretical reconstructions of their proportions and tonnages with those of known ships, official regulations, and tonnage formulas. Despite the unquestionable changes in ship design during these centuries, the similarities outweigh the differences and encourage confidence in this comparative method, at least as an approximation. The measures of the *San Esteban* in Table 2, wrecked in 1554 off the Texas coast, have been estimated using quite fragmentary remains. The result is not very satisfactory.

The tonnage calculated by Method 1, based on those estimates, seems far too small for the contents the ship carried on that final voyage.[28] It is also much smaller than the tonnage listed in contemporary sources.[29] Based on this preliminary test, the estimated measures for the *San Esteban* need to be revised.

Which brings me back full circle to Columbus's ships. Two well-known modern estimates for the ships' configurations come from Carlos Etayo Elizondo and José María Martínez-Hidalgo Terán, revising the estimates of several other scholars from the late nineteenth century onward.[30] Etayo claims there were two different *Niñas* on Columbus's first two voyages. He also calculated the measures of all three ships on the first voyage as considerably smaller than previous authors had argued. Etayo based his estimates on a close and careful reading of contemporary sources, including Escalante's remark that Columbus's ships were small, with the largest "very little larger than 100 *toneladas*."[31] Assuming that Escalante's figures were in the *toneladas* used in Seville for merchandise, and not the *toneles machos* of Vizcaya that Measured 1.2 times larger, he adjusted his figures accordingly. Etayo also assumed that García de Palacio used the *tonelada* of Seville. His final figures are provided in Table 2, and he believed so strongly in them that he sailed the Atlantic in a reconstruction of the *Niña* he envisioned.[32] The verdict thus far, however, is that there was only one *Niña* and that Etayo's estimates are too small, for a variety of reasons.

Martínez-Hidalgo's reconstructions have generally been preferred. His estimates for the *Santa María*, based on the conclusion that the ship was a *nao*, fall well within the range for *naos*, both real and ideal, in Tables 1 and 2. He accepted Escalante's estimate for the tonnage of the *Santa María* without revision. The result is a *nao* supposedly measuring 105.9 *toneladas*.[33] By Method 1, however, it measures nearly 2.4 times that size, as Table 2 demonstrates. I would agree with Etayo that Martínez-Hidalgo's figures for the *Santa María* are too high. Martínez-Hidalgo's estimates for the *Pinta* and the *Niña* were based on proportions for caravels in the Portuguese *Livro nautico*.[34] That is certainly plausible, and the tonnages he gives are plausible as well — about 61 *toneladas* for the *Pinta* and 53 for the *Niña*. The problem, however, is that his measurements indicate far larger tonnages, when calculated by Method 1.

How can we solve the dilemmas presented by every estimate of Columbus's ships so far? The answer, it seems to me, lies in the use of contemporary methods of measuring ship tonnages and in the study of contemporary ship configurations. Surprisingly, neither Etayo nor Martínez-Hidalgo made use of what I have called Method 1, which was the official method of gauging Spanish ships from 1590 on, and was undoubtedly in use much earlier. García de Palacio used Method 1 for the ideal ships in his treatise. The correspondence between the figures he gave and calculations by Method 1 are too close to permit another interpretation. And Method 1, as we know from the discussion above, calculated tonnage in the *tonel macho*

of Vizcaya. That is an important point. Etayo was mistaken in thinking García used the smaller merchandise *tonelada*.

Furthermore, as I maintain above, Escalante used the *tonel macho* as well, which had become standard for gauging ships by the time he wrote. The smaller *tonelada* of Seville seems to have been used when merchandise capacity was the central concern Though the same ship could be described by several different measures, contemporaries knew the difference. After the passage of several centuries, we no longer have that knowledge and are forced to reconstruct it. With that accomplished, we can take Escalante's "very little larger than 100 *toneladas*" and proceed to a new set of estimates for Columbus's ships.

The most trustworthy information we have concerns the number of crew members on Columbus's first voyage. The late Alice Bache Gould painstakingly researched the lives of every man on the voyage and was able to confirm identification for 87 of them. With 90 as a usable minimum, she concluded that 40 men would have been on the *Santa María*, 30 on the *Pinta*, and 20 on the *Niña*, which agrees well with other estimates of the relative sizes of the three ships.[35] With the *Santa María* at just over 100 *toneladas*, the resulting manning ratio is 2.5 *toneladas* per man, a figure somewhat high but still consonant with many others for the sixteenth and seventeenth centuries.[36] Applying the same ratio to the two caravels gives us estimates of 75 *toneladas* for the *Pinta* and 50 for the *Niña*. Michele de Cuneo, who accompanied Columbus on his second voyage, wrote that the *Niña* was about 60 *toneladas*.[37] If, despite Etayo's claim, the same *Niña* sailed on both the first and second voyages, we should estimate the smallest of Columbus's three ships at somewhere between 50 and 60 *toneladas*. For the sake of argument, I will estimate it at 55.

The proportions of *naos* and caravels provide the next piece in the puzzle. A plausible set of figures for the *nao Santa María* is the simple "as, dos, tres" described above, so that the keel would be twice the beam, and the length three times the beam. The depth can be estimated at half the beam. Or, we can use Martínez-Hidalgo's proportions, which are nearly identical. We can assume that the caravels were somewhat slimmer and shallower than the *nao*, but we cannot be sure how much. To provide a range of possibilities, I will calculate three separate sets of figures: one based on the Portuguese configurations used by Martínez-Hidalgo, a second based on the 1624 corsairing frigate listed in Table 2, and a third based on the proportions that *don* Diego Brochero recommended for dispatch boats in 1608. As more information becomes available from documents and wrecks of the period, those estimates can easily be adjusted.

The final step is to insert the estimated tonnages and configurations into the formula for Method 1, using "X" as the beam, and proportions of "X" as the other measures, in *codos*. It is important that the measures all be in *codos*, because the formula depends upon the value of the *tonelada* as 8 cubic *codos*. For example, using Martínez-Hidalgo's proportions for the

Santa María, X is the beam, .49X is the depth, and 2.98X is the length on deck, with the total tonnage at 105.9 *toneladas*. The formula is then:

$$\frac{\dfrac{(0.49X)\,(X)}{2}\,(2.98X)}{8} = 105.9$$

The value of X, representing the beam, works out to 10.51 *codos*. The other dimensions come from their value in proportion to the beam. This gives a keel of 21.02, a length on deck of 31.32, and a depth in the hold of 5.15 *codos*, for the estimated tonnage of 105.9 *toneladas*. We could just as easily use the classic proportions of "as, dos, tres" and 100 *toneladas*, which would vary the final measurements slightly. My own choice is for a ship 10.5 *codos* in the beam, 21 in the keel, 31.5 in length, and 5.25 in depth, with a total of 108.5 *toneladas*.

Applying the same procedure to the two caravels, with three possible sets of measurements for each, gives the results entered on Table 2 as Phillips-1, 2, and 3, for which I used the estimate of 75 *toneladas* for the *Pinta*, and 55 *toneladas* for the *Niña*. The method works equally well for the *San Esteban* (1554), using proportions midway between "as, dos, tres" and those for García's 1587 *nao*, with the tonnage estimated by Chaunu as 200 *toneladas*. (See Table 2.)

The method I have described has the merit of estimating ships that conform to the tonnage definitions understood by contemporaries, based on the proportions of ships common at the time. Most important, it uses the calculation of tonnage that was current for Spanish ships. Much of the confusion and wildly differing estimates we have for Columbus's ships to date can be traced directly to the use of modern measures, rather than contemporary ones. Martínez-Hidalgo, Etayo, and the many other scholars who have labored over this problem have done a great service for scholarship. Their specialized knowledge of rigging and other nautical matters has made invaluable contributions to our knowledge of seafaring in the past. Yet they left nagging doubts in two of the key questions regarding Columbus's ships: how large were they and what were their configurations? By taking a closer look at the pertinent documents, I hope to have clarified those questions. If my findings are borne out by further study, they will have important implications for reconstructions of Columbus's ships now under way. They will also provide a method and comparative data for scholarly work on other historical ships as the quincentenary approaches.

NOTES

1. Cesáreo Fernández Duro, ed., *Disquisiciones náuticas*, 6 vols. (Madrid, 1876-81), 5, pp. 150-54, regulations of August 20, 1590.

2. Martín Fernández de Navarrete, comp., *Colección de documentos y manuscriptos compilados*, ed. by Julio Guillén Tato, 32 vols. (Nendeln, Lichtenstein, 1971), 23(1), doc. 47, pp. 575-93.

3. See the official regulations from 1618 in the Archivo General de Marina, Museo Naval, Madrid (hereafter AGM), Caja Fuerte 134. The regulations are reprinted in *Recopilación de leyes de los reynos de las Indias, mandadas imprimir y publicar por el Magestad católica del rey don Carlos II*, 3 vols. (Madrid, 1681; repr. Madrid: Consejo de la Hispanidad, 1943), libro 9, título 28, ley 22, 3, pp. 340-62.

4. L. G. Carr-Laughton, "English and Spanish Tonnage in 1588," *Mariner's Mirror* 44 (1958), 151-154.

5. Thomas Heywood, *A True Description of His Majesties Royall Ship, Built this Yeare 1637 at Wooll-witch in Kent* (London, 1637), pp. 44-48.

6. Frederic C. Lane, *Venetian Ships and Shipbuilders of the Renaissance* (Baltimore, 1934), pp. 235-37, tables giving the measurements of various European ships.

7. See the discussion of tonnage calculations below.

8. Diego García de Palacio, *Instrucción náutica para navegar* (Mexico, 1587; repr. Madrid, 1944).

9. Fernando de Oliveira, *Livro da fabrica das naos*, ed. by Henrique Lopes de Mendonca, as *O padre Fernando Oliveira e a sua obra nautica* (Lisbon, 1898).

10. Juan Escalante de Mendoza, *Itinerario de navegación de los mares y tierras occidentales* (Madrid, 1575), in Fernández Duro, *Disquisiciones náuticas*, 5, pp. 413-515. The original manuscript is in the Biblioteca Nacional, Madrid.

11. See the discussion of tonnage calculations below.

12. García de Palacio, *Instrucción náutica*, fols. 90-92. The *codo* was the standard linear measure for Spanish ships. The printed 1618 regulations in AGM, Caja Fuerte 134, contain an exact scale for a quarter-*codo*, equal to 5.5 inches. Unfortunately, the 1943 reprinted edition is photographically reduced, so that the quarter-*codo* appears shorter than it should. *Recopilación de leyes de Indias*, libro 9, título 28, ley 22, 3, p. 362.

13. This is sometimes interpreted as one unit of depth for two units of beam, and three of length, but that is less plausible.

14. G. P. B. Naish, "Ships and Shipbuilding," in *A History of Technology*, ed. Charles Singer, et al, 7 vols. (Oxford, 1954-78), 3, p. 472; Lane, *Venetian Ships and Shipbuilders*, p. 236.

15. Escalante de Mendoza, *Itinerario*, in Fernández Duro, *Disquisiciones náuticas*, 5, p. 457.

16. Michael Barkham, "Sixteenth Century Spanish Basque Ships and Shipbuilding: The Multipurpose *nao*," in *Postmedieval Boat and Ship Archeology*, ed. Carl Olof Cederlund (Stockholm, 1985), pp. 114-116.

17. AGM, Colección Navarrete, IX, doc. 27, fols. 309-10. See Table 2.

18. Applying the formula for tonnage in merchant ships (Method 1 in Table 1) to the revised measurements from García gives a result of 397.81 *toneladas*.

19. See Michel Morineau, *Jauges et méthodes de jauge anciennes et modernes* (Paris, 1966), pp. 31-34, 64, 115-16, for a useful discussion of the *tonelada*, including critiques of other interpretations of its value, and a bibliography. Morineau mentions the *tonneau de mer* as 1.42 cubic meters. Horace Doursther, *Dictionnaire universel des poids et mesures* (1840; repr. Amsterdam, 1965), p. 541, lists it as 1.4396 cubic meters. Although I agree with Morineau on the approximate value of the *tonelada*, I disagree with several other points in his argument. I plan to write a brief article on the *tonelada* soon.

20. Escalante de Mendoza, *Itinerario*, in Fernández Duro, *Disquisiciones náuticas*, 5, pp. 461-62.

21. *Recopilación de leyes de Indias*, libro 9, título 28, ley 25, 3, pp. 363-369, contains the 1613 rules. A document from 1742 repeated the formula, mentioning that 14% more should be added to warships. AGM, ms. 439, doc. 1, fols. 1-3. This was the same net difference between merchant and war vessels as in the earlier formulas.

22. Escalante de Mendoza, *Itinerario*, in Fernández Duro, *Disquisiciones náuticas*, 5, p. 457. He wrote that for every 5 *codos* of keel, a ship should have 2-1/5 *codos* of beam and 7 *codos* of length on deck.

23. Tomé Cano, *Arte para fabricar y aparejar naos (1611)*, ed. Enrique Marco Dorta (La Laguna, Canary Islands, 1964), p. 67; "Diálogo entre un vizcaíno y un montañés," (ca. 1635), in Fernández Duro, *Disquisiciones náuticas*, 6, pp. 115-16.

24. The Venetin foot, at 13.691 English inches, was equivalent to .62 *codos*. Doursther, *Dictionnaire universel*, p. 418. The Venetian *botta*, calculated by Lane at 25.51 cubic English feet in capacity, was equivalent to 1.65 *toneladas*. Lane, *Venetian Ships and Shipbuilders*, p. 246.

25. Auguste Jal, *Abraham du Quesne et la marine de son temps*, 2 vols. (Paris, 1873), 1, pp. 87-88; Cesáreo Fernández Duro, *Armada española desde la unión de los reinos de Castilla y de León*, 9 vols. (Madrid, 1895-1903), 4, p. 173.

26. From a document printed in Rafael Estrada y Arnáiz, *El Almirante don Antonio de Oquendo* (Madrid, 1943), pp. 128-30.

27. Edmond Pâris, *Souvenirs de marine*, 6 vols. (Paris, 1886-1910), 3, plates 122-24. A selection of 26 plates published in 1882 also included the *Couronne*.

28. David McDonald and J. Barto Arnold, III, eds. *Documentary Sources for the Wreck of the New Spain Fleet of 1554* (Austin, 1979), pp. 151-58, 164-68.

29. Pierre Chaunu and Huguette Chaunu, *Séville et l'Atlantique*, 8 vols. in 12 (Paris, 1955-59), 2, pp. 484-85, 520-21. The *San Esteban*, master Francisco del Huerto, was listed at an estimated 200 *toneladas*. Though Chaunu included it among the ships in the 1555 outbound fleet to New Spain, it is highly probable that this was the same ship that sank in 1554. See n. 28 above for its salvage records.

30. Carlos Etayo Elizondo, *La expedición de la "Niña II"* (Barcelona, 1963), and the same author's *Naos y carabelas de los descubrimientos y las naves de Colón* (Pamplona, 1971). José María Martínez-Hidalgo Terán, *Columbus's Ships*, ed. Howard I. Chapelle (Barre, Mass., 1966). Etayo presents an extensive analysis and critique of earlier estimates in *Naos*, pp. 217-41.

31. Escalante de Mendoza, *Itinerario*, in Fernández Duro, *Disquisiciones náuticas*, 5, p. 445.

32. Etayo, *Naos*, pp. 165, 217-18, 230, 235.

33. Martínez-Hidalgo, *Columbus's Ships*, pp. 40-42. The author argued that Escalante used the Seville "tun," but he considered that worth 8 cubic *codos* (1. 4 cubic meters). The Vizcaya ton he considered worth 1.683 cubic meters. I disagree with both these points. See n. 19 above.

34. *Ibid.*, pp. 96-100. *Livro nautico* is a common variant for the name of Fernando de Oliveira's *Livro da fabrica das naus* (ca. 1565). See n. 9 above.

35. Alicia B. Gould, *Nueva lista documentada de los tripulantes de Colón en 1492* (Madrid, 1984), pp. 53-56. This welcome volume is a compilation of articles published by Gould between 1924 and 1944. She died in 1953.

36. Carla Rahn Phillips, *Six Galleons for the King of Spain: Imperial Defense in the Early Seventeenth Century* (Baltimore, 1986), pp. 42-43, 140, and notes.

37. *Raccolta di documenti e studi pubblicati dalla Reale Commissione Colombiana* (Rome, 1892-96), III, ii, p. 103.

38. Escalante de Mendoza, *Itinerario*, 5, pp. 456-58.

39. García de Palacio, *Instrucción náutica*, fols. 90-97v.

40. Navarrete *Colección de documentos*, 23 (1), doc. 47, pp. 575-93.

41. AGM, Marqués de la Victoria, "Diccionario demonstrativo, con la configuración o anathomía de toda la architectura naval moderna," plate 5.

42. Fernández Duro, *Disquisiciones náuticas*, 5, p. 54.

43. Cano, *Arte para fabricar y aparejar naos*, pp. 66-69.

44. Gervasio Artiñano y de Galdácano, *La arquitectura naval española (en madera)* (Madrid, 1920), pp. 128-29.

45. Navarrete, *Colección de documentos*, 24 (1), doc. 15, pp. 133-42.

46. AGM, Caja Fuerte 134, printed in *Recopilación de leyes de Indias*, libro 9, título 28, ley 22, 3, pp. 340-62.

47. "Diálogo" in Fernández Duro, *Disquisiciones náuticas*, 6, pp. 111-129.

48. José Pérez Vidal, *Díaz Pimienta y la construcción naval española en el siglo XVII* (Las Palmas, 1936), pp. 24-28.

49. Artiñano, *Arquitectura naval*, pp. 128-29; *Recopilación de leyes de Indias*, libro 9, título 28, ley 23, 3, pp. 362-63, undated.

50. Artiñano, *Arquitectura naval*, pp. 128-29; *Recopilación de leyes de Indias*, libro 9, note following título 28, 3, pp. 371-72.

51. Artiñano, *Arquitectura naval*, pp. 128-29.

52. Martínez-Hidalgo, *Columbus's Ships*, p. 42.

53. Etayo, *Naos*, p. 165.

54. Calculated using Method 1, and estimated proportions and tonnages. Sources for the tonnage estimates are as follows: *Santa María*, n. 31; *Niña*, n. 37; *Pinta*, n. 35; *San Esteban*, n. 29; *La Couronne*, n. 25.

55. Institute for Nautical Archeology (INA) exhibit, Museum of Texan Cultures, San Antonio, Texas, April 1984.

56. Barkham, "Basque Ships," p. 114.

57. AGM, Colección Navarrete, IX, doc. 27, fols. 309-310.

58. Archivo General de Simancas (AGS), Contaduría Mayor de Cuentas, 3a Época, leg. 2214, no. 7.

59. AGS, Guerra Antigua, leg. 3150.

60. Archivo General de Indias, Seville (AGI), Contratación, 41-1-2/13, cited in Abbott Payson Usher, "Spanish Ships and Shipping in the Sixteenth and Seventeenth Centuries," in *Facts and Factors in Economic History: For Edwin Francis Gay* (Cambridge, Mass., 1932; repr. New York, 1967), p. 201.

61. AGS, Guerra Antigua, leg. 3149, no. 2.

62. AGM, ms. 1311, fol. 86.

63. AGM, Colección Vargas Ponce, XVII, doc. 262, fol. 454.

64. Lane, *Venetian Ships and Shipbuilders*, pp. 235-37. All but the 1608 Venetian figures list length on the second deck, not the first. The 1420 figure for beam is on the second deck as well, and there is some confusion as to where the depth was measured on all the ships.

65. Oliveira, *Livro da fabrica das naus*, pp. 178-206. The Portuguese measures have been reduced to Spanish ones, based on 1 *palmo de goa* being equal to about 250 mm or 9.8425 inches, and 1 Portuguese *tonel* being equal to 2.0754 cubic meters. The latter figure comes from Doursther, *Dictionnaire universel*, p. 541.

66. Pâris, *Souvenirs de marine*. The second set of figures results from taking the beam measurement from Pâris, then assigning the other measures according to proportions in Spanish warships of the time.
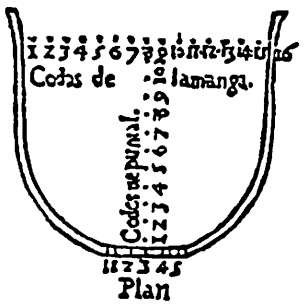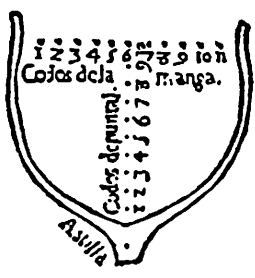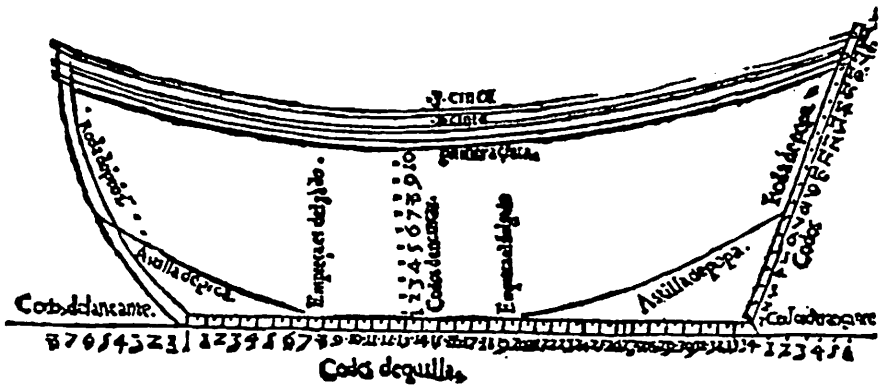
Fig. 1. Ship of 400 _toneladas_, showing its profile (top) and cross-sections of its hull at the prow, master ribs, and poop.

(García de Palacio, _Instrucción náutica_, fols. 93v–94.)

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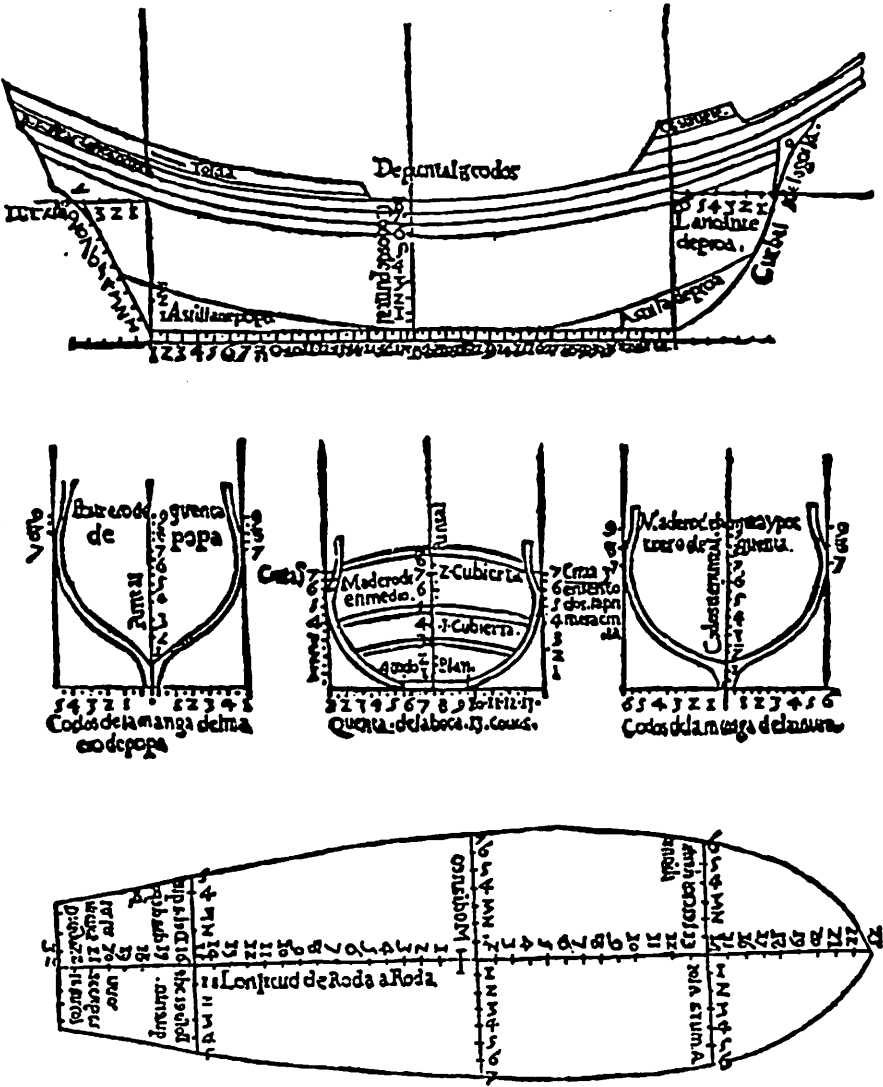
Fig. 2. Ship of 150 *toneladas*, showing its profile (top) cross-sections of the hull at the poop, master ribs, and prow (middle); and lower deck (bottom). Note that some of the labels on the lower deck illustration have been printed backwards. (García de Palacio, *Instrucción náutica*, fols. 96-97.)

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Table 1
Ideal Measures and Estimated Tonnages of Ships According to Spanish Nautical Treatises and Memoranda
(linear measures in *codos* of 22 inches)

	Beam	Keel	Length on Deck	Depth in Hold	Floor	Toneladas Method 1	Toneladas Method 2	Given in Source	Keel to Beam	Depth to Beam	Length to Beam	Floor to Beam	Source
Escalante de Mendoza (1575)	19.4	44 ·	61.60						2.27		3.18		38
	18.5	42	58.80						2.27		3.18		
	16.7	38	53.20						2.27		3.18		
García de Palacio (1587)	16.0	34	51.33	7.75		397.81	453.50	400.00	2.13	0.48	3.21		39
	12.0	34	45.00	4.50		152.19	173.50	150.00	2.83	0.37	3.74		
Ordenanzas (1607)	19.0	47	65.00	10.00		771.88	879.94	897.38	2.47	0.53	3.42		40
	18.0	44	62.00	9.50		662.63	755.39	755.00	2.44	0.53	3.44		
	17.0	43	60.00	9.25		589.69	672.24	669.38	2.53	0.54	3.53		
	16.0	42	57.00	8.75		498.75	568.58	567.88	2.63	0.55	3.56		
	15.0	40	52.00	8.00		390.00	444.60	487.13	2.67	0.53	3.47		
	14.0	39	50.00	7.50		328.13	374.06	373.38	2.79	0.54	3.57		
Juan de Veas (ca. 1608)	15.0	42							2.80				41
	14.0	40							2.86				
	13.0	38							2.92				
	12.0	36		6.00					3.00	0.50			

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Table 1 (continued)

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Beltrán and Echevarri (ca. 1608)	18.5	45	60.00	11.10		770.06	877.87	1000.00	2.43	0.60	3.24		42
Tomé Cano (1611)	18.0	48							2.67				43
	17.0	46							2.71				
	16.0	44							2.75				
	15.0	42							2.80				
	14.0	40							2.86				
	13.0	38							2.92				
	12.0	36	46.50	7.00	6.00	244.13	278.30	232.00	3.00	0.58	3.88		
								278.42					
Ordenanzas (1613)	20.0	51	66.00	10.00		825.00	940.50	833.63	2.55	0.50	3.30		44
	18.0	48	61.50	9.00		622.69	709.86		2.67	0.50	3.42		
	17.0	46	58.75	8.50		530.59	604.87	539.25	2.71	0.50	3.46		
Urquiola (ca. 1613)	14.5	36	47.00	7.00		298.16	339.90	360.00	2.48	0.48	3.24		45
Ordenanzas (1618)	20.0	49	63.00	9.50	10.00	748.13	852.86	821.88	2.45	0.48	3.15	0.50	46
	19.0	48	61.50	9.00	9.50	657.28	749.30	721.75	2.53	0.47	3.24	0.50	
	18.0	46	59.00	8.50	9.00	564.19	643.17	624.50	2.56	0.47	3.28	0.50	
	17.0	44	56.00	8.00	8.50	476.00	542.64	530.00	2.59	0.47	3.29	0.50	
	16.0	42	53.00	7.50	8.00	397.50	453.15	444.50	2.63	0.47	3.31	0.50	
	15.0	40	50.50	7.00	7.50	331.41	377.80	371.50	2.67	0.47	3.37	0.50	
	14.0	38	48.00	6.50	7.00	273.00	311.22	309.50	2.71	0.46	3.43	0.50	

Table 1 (continued)

Basque nao (1611)	14.8	30	46.00	7.67		325.26	370.79		2.00	0.52	3.12		56
Corsairing frigates (1624)	9.0	30	34.00	4.00		76.50	87.21		3.33	0.44	3.78		59
Ships Being Repaired in Seville (1625)	19.5	47	59.57	9.04	8.99	655.30	747.05	656.00	2.43	0.46	3.06	0.46	60
	19.5	49	60.11	8.78	8.99	642.23	732.14	655.00	2.53	0.45	3.09	0.46	
	19.5	46	58.24	8.78	8.99	622.25	709.36	619.50	2.38	0.45	2.99	0.46	
	19.3	48	60.74	10.00	8.99	731.16	833.52	736.00	2.51	0.52	3.15	0.47	
	19.2	45	57.82	8.88	8.51	614.53	700.56	605.00	2.34	0.46	3.02	0.44	
	18.8	47	59.57	9.04	8.99	633.76	722.49	642.00	2.49	0.48	3.16	0.48	
	18.5	47	59.04	8.88	8.99	606.52	691.43	615.00	2.56	0.48	3.19	0.49	
	18.5	47	59.04	8.78	8.51	599.69	683.65	604.00	2.56	0.47	3.19	0.46	
	17.6	45	57.45	9.04	8.51	569.66	649.41	584.00	2.56	0.52	3.27	0.48	
	17.2	44	54.79	9.20	7.98	542.82	618.81	551.50	2.56	0.53	3.18	0.46	
	17.2	42	50.00	8.51	7.98	456.88	520.84	456.00	2.46	0.50	2.91	0.46	
	16.5	42	51.86	8.19	7.50	437.74	499.02	441.00	2.53	0.50	3.14	0.45	
	16.2	41	50.69	8.51	7.23	435.96	496.99	442.00	2.55	0.53	3.13	0.45	
	16.0	38	47.98	7.29	6.97	349.99	398.99	338.50	2.38	0.46	3.00	0.44	
	15.7	41	50.85	8.03	6.97	400.41	456.47	404.75	2.60	0.51	3.24	0.44	
	15.5	43	53.35	9.04	6.97	466.61	531.94	470.00	2.77	0.58	3.45	0.45	
	15.4	39	49.47	7.34	6.49	350.17	399.20	347.00	2.54	0.48	3.21	0.42	
	15.0	41	52.39	8.67	6.97	425.83	485.45	437.50	2.71	0.58	3.49	0.46	
	14.8	38	48.30	7.50	6.49	334.85	381.73	341.50	2.58	0.51	3.27	0.44	
	14.7	40	50.32	8.03	6.97	372.00	424.08	346.00	2.74	0.55	3.42	0.47	
	14.5	41	50.53	7.82	6.49	357.36	407.39	357.75	2.85	0.54	3.49	0.45	
Average of 21 ships	17.1	43	54.39	8.54	7.83	505.03	575.74	507.14	2.55	0.50	3.19	0.46	

Table 1 (continued)

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"Diálogo" (ca. 1635)	22.0	66	80.67	12.00	11.00	1331.06	1517.40		3.00	0.54	3.67	0.50	47
	21.0	63	77.00	11.50	10.50	1162.22	1324.93		3.00	0.55	3.67	0.50	
	20.0	60	73.50	11.00	10.00	1010.63	1152.11		3.00	0.55	3.68	0.50	
	19.0	57	69.67	10.50	9.50	868.70	990.32		3.00	0.55	3.67	0.50	
	18.0	54	66.00	10.00	9.00	742.50	846.45		3.00	0.56	3.67	0.50	
	17.0	51	62.50	9.50	8.50	630.86	719.18		3.00	0.56	3.68	0.50	
	16.0	48	58.67	9.00	8.00	528.03	601.95		3.00	0.56	3.67	0.50	
	15.0	45	55.00	8.50	7.50	438.28	499.64		3.00	0.57	3.67	0.50	
	14.0	42	51.00	8.00	7.00	357.00	406.98		3.00	0.57	3.64	0.50	
Díaz Pimienta (ca. 1645)	18.5	55	67.00	9.50	9.50	735.95	838.99		2.97	0.51	3.62	0.51	48
Ordenanzas (1666)	18.5	53	65.00	8.75	9.58	657.62	749.68	700.00	2.86	0.47	3.51	0.52	49
	17.5	50	62.00	8.25	9.00	559.45	637.78	500.00	2.86	0.47	3.54	0.51	
Ordenanzas (1679)	19.0	56	67.50	9.25	9.75	741.45	845.25	800.00	2.92	0.49	3.55	0.51	50
Garrote (1691)	22.0	66	75.62	8.69		903.56	1030.06	894.25	3.00	0.40	3.44		51
	18.0	54	61.80	7.14		496.41	565.91	487.88	3.00	0.40			

Table 2
Measures and Estimated Tonnage of Real Ships Using Spanish Measuring Conventions
(linear measures in *codos* of 22 inches)

	Beam	Keel	Length on Deck	Depth in Hold	Floor	Toneladas[#] Method 1	Toneladas[#] Method 2	Given in Source	Keel to Beam	Depth to Beam	Length to Beam	Floor to Beam	Source
SANTA MARÍA (1492)													
Martínez-H	14.0	28	41.84	6.82		250.39	285.45	105.90	2.00	0.49	2.98		52
Etayo	10.2	18	25.05	7.64		122.01	139.09		1.79	0.75	2.46		53
Phillips	10.5	21	31.50	5.25		108.53	123.72		2.00	0.50	3.00		54
PINTA (1492)													
Martínez-H	12.0	29	37.32	5.18		144.63	164.87	60.91	2.39	0.43	3.12		52
Etayo	7.3	17	22.37	3.94		40.38	46.03		2.29	0.54	3.05		53
Phillips-1	9.6	23	30.08	4.14		75.03	85.53		2.39	0.43	3.12		54
Phillips-2	9.0	30	33.91	3.95		75.09	85.61		3.33	0.44	3.78		54
Phillips-3	8.5	30	35.70	3.98		75.13	85.65		3.50	0.47	4.22		54
NIÑA (1492)													
Martínez-H	11.4	27	35.63	4.96		126.14	143.80	52.72	2.40	0.43	3.12		52
Etayo	6.0	15	20.85	3.51		27.49	31.34		2.56	0.58	3.47		53
Phillips-1	8.7	21	27.14	3.74		55.19	62.92		2.40	0.43	3.12		54
Phillips-2	8.1	26	30.58	3.56		55.04	62.75		3.21	0.44	3.78		54
Phillips-3	7.6	27	32.16	3.58		54.83	62.51		3.50	0.47	4.22		54
SAN ESTEBAN (1554)	10.8	23	36.60	5.18		127.97	145.89		2.13	0.48	3.39		55
Phillips	12.8	26	39.78	6.28		200.17	228.19	200.00	2.06	0.49	3.10		54
Basque nao (1577)	16.8	33	57.00	9.50		566.88	646.25		1.94	0.57	3.40		56

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Table 2 (continued)

SANTIAGO* (ca. 1580)	20.5	45	64.00	13.50	7.25	1107.00	1261.98	1050.00	2.17	0.66	3.12	0.35	57
SANTÍSSIMA TRINIDAD Y SAN VICENTE* (ca. 1580)	19.0	44	63.00	10.50	6.30	785.53	895.51	1000.00	2.29	0.55	3.32	0.33	57
SAN GERÓNIMO* (ca. 1580)	19.8	47	65.50	13.50	7.50	1091.50	1244.31	1200.00	2.38	0.68	3.32	0.38	57
SAN PEDRO* (ca. 1580)	19.5	46	65.00	13.25	7.25	1049.65	1196.60	1060.00	2.33	0.68	3.33	0.37	57
SAN MATEO Y SAN FRANCISCO* (ca. 1580)	19.0	42	62.00	10.50	6.30	773.06	881.29	900.00	2.23	0.55	3.26	0.33	57
SANTA MARÍA LA ANUNCIADA* (ca. 1580)	18.8	41	60.00	10.00	6.00	703.13	801.56	900.00	2.19	0.53	3.20	0.32	57
SAN SALVADOR* (ca. 1580)	18.5	40	60.50	10.30	6.20	720.52	821.39	900.00	2.16	0.56	3.27	0.34	57
SAN PEDRO Y PABLO+ (ca. 1580)	18.5	41	59.75	10.00	6.00	690.86	787.58	900.00	2.20	0.54	3.23	0.32	57
SANTA MARÍA DE LORETO* (ca. 1580)	18.3	39	53.50	11.00	5.75	673.10	767.33	800.00	2.13	0.60	2.92	0.31	57
SANTO ESPÍRITO* (ca. 1580)	17.8	38	51.00	9.30	5.50	526.18	599.84	700.00	2.14	0.52	2.87	0.31	57

Table 2 (continued)

SANTÍSSIMA TRINIDAD+ (ca. 1580)	15.0	38	53.50	11.00	5.75	551.72	628.96	700.00	2.50	0.73	3.57	0.38	57
SANTA MARÍA Y SAN JUAN BAPTISTA++ (ca. 1580)	15.0	33	52.50	8.00	5.30	393.75	448.88	560.00	2.17	0.53	• 3.50	0.35	57
Basque nao (1584)	15.0	28	46.00	8.75		377.34	430.17		1.87	0.58	3.07		56
Basque nao (1585)	16.5	30	53.00	7.75		423.59	482.89		1.82	0.47	3.21		56
Basque nao (1596)	15.0	27	47.00	7.00		308.44	351.62		1.80	0.47	3.13		56
Basque nao (1600)	14.0	28	43.00	8.50		319.81	364.59		2.00	0.61	3.07		56
Basque nao (1601)	16.0	31	51.00	9.50		484.50	552.33		1.94	0.59	3.19		56
Bertendona's warships (1603)	18.8		60.50	10.90		774.85	883.33	889.63		0.58	3.12		58
	17.4		55.25	8.80		528.74	602.77	605.67		0.50	3.18		
	16.6		53.30	8.75		483.86	551.61	551.50		0.53	3.21		
	16.3		52.50	9.00		481.36	548.75	549.86		0.55	3.22		
	16.2		53.67	8.50		461.90	526.56	535.75		0.52	3.31		
	15.6		48.50	8.25		390.12	444.74	444.33		0.53	3.12		
	15.3		47.30	8.00		361.85	412.50	413.75		0.52	3.09		
	10.2		36.30	5.33		123.34	140.61	140.50		0.52	3.56		
	10.1		37.20	4.75		111.54	127.16	127.40		0.47	3.68		

Table 2 (continued)

N.S. BEGOÑA (1627)	18.0	44	56.75	8.50	8.50	542.67	618.65	541.50	2.44	0.47	3.15	0.47	61
SAN FELIPE (1627)	18.0	44	56.00	8.50	8.50	535.50	610.47	537.38	2.47	0.47	3.11	0.47	61
SAN JUAN BAPTISTA (1627)	17.0	42	53.50	8.00	8.00	454.75	518.42	455.75	2.47	0.47	3.15	0.47	61
LOS TRES REYES (1627)	17.0	42	53.33	8.00	8.00	453.31	516.77	455.00	2.47	0.47	3.14	0.47	61
SANTIAGO (1627)	15.2	38	49.50	7.12	7.00	334.82	381.69	338.50	2.50	0.47	3.26	0.46	61
SAN SEBASTIÁN (1627)	15.0	38	48.67	7.17	7.00	327.15	372.96	330.25	2.53	0.48	3.24	0.47	61
ENCARNACIÓN (1646)	17.1	47	58.00	8.75	8.56	542.39	618.33	557.00	2.75	0.51	3.39	0.50	62
Basoanaga galleon (1668)	18.5	53	66.00	8.25	9.67	629.58	717.72		2.86	0.45	3.57	0.52	63

Table 3
Measures of Selected Ships from Non-Spanish Sources

Mediterranean Cog, c. 1410									2.50	0.49	3.60		64
Venice nave (1420)	16.7	40	58.90	5.42		333.20	379.85	303.00	2.41	0.32	3.53		64
Venice round ship, 1450	15.5	45		6.82	5.58			303.00	2.92	0.44		0.36	64
Venice nave (1550)	12.4	31		4.03	4.34				2.50	0.33		0.35	64
Venice galleon (ca. 1550)									2.70	0.45	3.60		64
Portugal nau (ca. 1565)	21.5	48	64.42	9.84	8.05	850.60	969.69	864.99	2.25	0.46	3.00	0.37	65
Burlioni nave (1591)	14.3	34		4.34	3.72			504.24	2.39	0.30		0.26	64
Steffano nave (1597)	12.4	33		3.72	4.03			363.64	2.63	0.30		0.27	64
Casotti nave (1599)	15.5	33		4.96				424.24	2.12	0.32			64
Steffano nave (1608)	13.0		40.92	3.72		141.32	161.11	300.00		0.29	3.14		64

Table 3 (continued)

LA COURONNE
(Fr. warship)

(ca. 1636)	26.4	69	87.75	9.69		1402.99	1599.41	2000.00	2.62	0.37	3.32		66
	26.4	69	86.62	12.41	12.41	1773.67	2022.75	2000.00	2.62	0.47	3.28	0.47	54

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*	Built by a Neapolitan
+	Built by a Venetian
++	Built by a Ragusan
#	Tonnages are calculated using two decimal places for each of the linear measures. Some of these are rounded off to conserve space in the table.

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