Ship Measurement and Admeasurement

One of the primary measurements frequently reported for a sailing vessel was the tonnage (or tunnage)[1]. Tunnage measurement was an attempt to describe the cargo capacity of a vessel based on measurable dimensions. The term tun and tunnage derived from a standard wine cask or tun. The dimensions and capacity of a tun changed over time and in different areas. The number of tuns (casks) of wine a vessel carried determined the customs fees. The most accurate method, of course, would be to load a vessel and count the number of containers stowed in the ship. This proved impractical – counting the containers of wine as ships got larger became labor intensive, and as different cargo types were included in a ship, the conversion to tuns became problematic. A number of methods for determining the internal capacity were implemented over a period of some 300 years, until the mid-nineteenth century when the Moorsom system was developed. For a detailed historical review, see the 19th century discussion by Moorsom[2] and the expanded listing in the series of articles by William Salisbury in *The Mariner's Mirror*[3].

Saulisbury (1966a) offers the following very concise description of admeasurement:

Some sort of tonnage measurement, based on some arbitrary and artificial unit of capacity or weight, was necessarily closely connected with the development of merchant shipping. Warships could be described satisfactorily by the number of men or guns carried or by the number of oars or men required to propel them, and even today some small craft can be classed by such 'natural' units. Ships designed to carry cargo, however and particularly those driven by sails-needed altogether different treatment. In default of statutory enactments, an artificial unit which was to be generally acceptable had to evolve by usage alone, and this demanded a state of economic activity in which large quantities of a common commodity were frequently shipped over a wide area.

While both calculation of displacement[4] and tunnage are attempts to determine volumetric measures, the approximations derived from tunnage measurements are at best a poor reflection of the true displacement volume, based very loosely on the length, breadth and depth of hold for a ship. They take no account of the actual shape of the vessel, particularly the immersed part (displacement volume) which is most important to ship performance. Figure 5 provides a simplified comparison of the challenge in using tunnage dimensions for displacement calculations. The length of keel can be described in several ways – the length between stem and stern post at a specific height, the length to the touch (in general, the length of the keel that "touches" the ground), or the keel for tunnage, which takes the length between two points (such

---

[1] Ton/tonnage: The terms "ton" and "tonnage" will be used for weights and displacements. Tun/tunnage: The term "tun" can describe both weight and volume, so to avoid confusion, these terms will be used for volumetric measures (admeasurement) or cargo capacity.
[2] Moorsom, *Admeasurement of Tonnage* 1853.
[3] Mariners Mirror, 52: 41–51, 173–180, 329–340 (1966); 53: 251–264 (1967) and 54: 69-76 (1968)
[4] Displacement: The amount of water displaced or put aside by a vessel afloat is termed her "displacement." This may be reckoned as a volume, when it is expressed in cubic feet, or as a weight, when it is expressed in tons... If a vessel is floating in equilibrium in still water, the weight of water she displaces must exactly equal the weight of the vessel herself with everything she has on board.

as the gun deck or perpendiculars) and then applies deductions for the rake of the stem and stern. None of the 3 lengths shown in Figure 1 actually represent the length of keel for tunnage – in general, it was somewhat less than the length of keel.

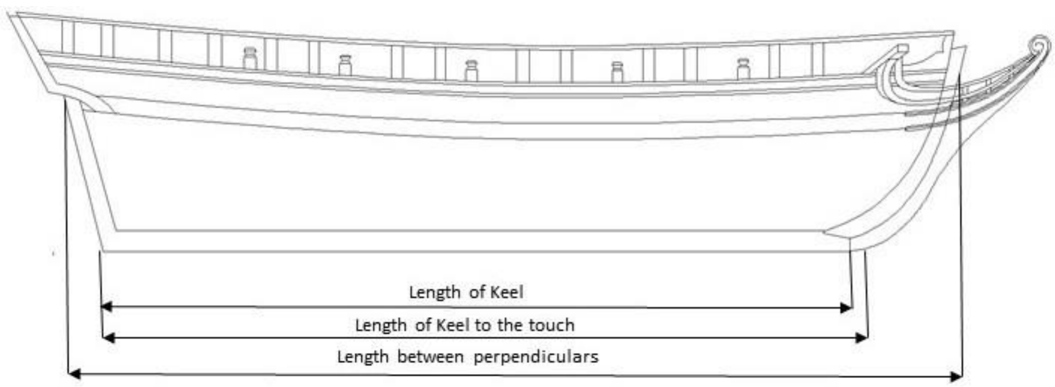

Figure 1. Comparison of length measurements (illustration by the author).

Many of the approaches to admeasurement for tunnage were based on "derived" rather than actual dimensions. In many, the maximum breadth was the key factor, while the length of keel for tunnage was a derived measurement (that is, it was not a measurable length but rather derived from other values as described in the examples below), and the depth of hold was, likewise, generally derived from the breadth. The result was that two vessels having the same breadth and length (whether on gun deck or between perpendiculars) would have the same tunnage, with no account of the shape of the ship. A sharp vessel with large dead rise would have the same tunnage as one with a flatter bottom and full body. While this was good for the collection of customs duties and for providing estimates for the construction of a ship, it was not equitable across vessels nor a true reflection of carrying capacity or displacement.

There are numerous methods that have been identified by Salisbury (among others) for measuring tunnage. To illustrate the challenge inherent in considering tunnage estimates provided for a vessel, the following five tunnage methods spanning some 200 years are compared for a single vessel of "known" dimensions.

Mr. Bakers Old Rule (from about 1582)[5]

The old way, which was established in Queen Elizabeth's time, and never questioned all King James time, is this: The length of the keel, leaving out the false post, if there be any. Multiply by the greatest breatdh within the plank, and that product by the depth taken from the breadth to the upper edge of the keel produceth a solid number which divided by 100 gives the contents in tons, into which add one third part for tonnage, so have you the tons and tonnage.

K = Length of keel excluding false post
B = greatest breadth within plank

[5] Described in Oppenheim, *Administration of the Royal Navy* page 266.

D = depth from B to upper edge of keel
Divisor = 100

Naval Papers of Peter Pett (about 1650)[6]

Take the Length from the inside on the Upper Deck between the Stem and the Sternpost, and the greatest Breadth from Outside to Outside: likewise, the Depth from the underpart of the Beam of the Upper Deck to the floor by the side of the Keelson. Multiply the Length by the Breadth, and that by the half Breadth, except the Depth exceed the half Breadth, then you are to multiply by that and divide the quotient by 110.

K = Inside on upper deck between stem and stern post
B = greatest breadth outside to outside
D = depth from underpart of beam to floor by side of the keelson or ½ B, whichever is greater
Divisor = 110

William Sutherland (1711)[7]

Some say the general method, which has been pitched upon by the greater number of Shipwrights and others, and may be termed Shipwrights Hall Rule, is to take the length of the keel, measured from the back of the main post to the foreside of the stem at the upper edge of the lower harping, by a perpendicular made from thence to the upper or lower edge of the keel, only 3/5 of the main breadth, from the outside of the plank of one side to the outside of the plank of the otherside, at the broadest place of the ship, being set backward or aftward from the right angle made by such a perpendicular and base. Observing also, that as several ships and vessels have no false post, in such a case there ought to be allowed 1/3 of the main post from the after part of such a stem post. Then to take the extreme breadth as aforesaid ... The half breadth is made use of instead of the depth in hold, which was formerly used; but then the ship's depth in hold and half breadth were very near equal; and now it is general to take the largest.

But not to enter upon disputes, the length as aforesaid is multiplied by the breadth, and again by half that breadth, and the sum being divided by 94, the quotient is the tunnage of the ship, for either sharp or full ships, merchant-men or men of war.

K = Back of stern post to foreside of stem at upper edge of lower harping less 3/5 main breadth
B = Greatest breadth outside to outside
D = larger of depth in hold or half breadth
Divisor = 94

An Act for Registering and Clearing Vessels, Regulating the Coasting Trade, and for other purposes. 1 September 1789[8].

SEC. 3. And be it further enacted, That to ascertain the tonnage of ships or vessels, the surveyor or other person appointed by the collector to measure the same, shall take the length of every vessel, if double decked, from the fore part of the main stem to the after part of the stern post

[6] Salisbury, W. 1967. "Early Tonnage Measurement in England: IV. Rules Used by Shipwrights, and Merchants."
[7] Sutherland, *The Ship-builder's Assistant*, 1711, p. 76. This same method was codified in 1773, and was frequently refered to as "builders Old Measure".
[8] United States Statutes at Large, Volume 1: 1st-5th, 1789-1799, Page 55.

above the upper deck, the breadth at the broadest part above the main wales, and half such breadth shall be accounted the depth of every double decked vessel; he shall then deduct from the length three fifths of the breadth, multiply the remainder by the breadth, and the product by the depth, dividing the product of the whole by ninety-five, the quotient shall be deemed the true contents or tonnage of such ship or vessel. To ascertain the tonnage of every single decked vessel, he shall take the length and breadth, as is directed to be taken for double decked vessels, and deduct three fifths in like manner, and the depth from the under side of the deck plank to the ceiling in the hold, and shall multiply and divide as aforesaid, and the quotient shall be deemed the true contents or tonnage of such single decked vessel.
K = length between fore part of stem and after part of sternpost minus 3/5 B
B = width at broadest part above main wales
D = depth from the under side of the deck plank to the ceiling in the hold
Divisor = 95

The General Rules Observed for Measuring the Tonnage of Ships in The King's and Merchants' Service (1805)[9].

Let fall a perpendicular from the foreside of the stem, at the height of the hawse-holes, and another perpendicular from the back of the main post, at the height of the wing transom.*

From the length between these perpendiculars, deduct three-fifths of the extreme breadth+, and likewise as many 2 ½ inches as the wing transom is high from the upper edge of the keel, and the remainder is accounted the length of the keel for tonnage. Then multiply the length of the keel for tonnage by the extreme breadth, and that product by half the extreme breadth; then, dividing by 94, the quotient will be the burthen in what is denominated Builder's Tonnage.

Or, Multiply the length of the keel for tonnage by the square of the extreme breadth, and divide the product by 188, the quotient will be the burthen in tons.

K = length from foreside stem at hawse holes to back of main post at wing transom minus 3/5 B minus 2 ½ "per height of wing transom above upper edge of keel.
B = extreme breadth outside to outside
D = ½ B
Divisor = 94

** In the merchant-service, this perpendicular is let fall from the foreside of the stem, at the height of the wing transom, by reason of the hawse-holes being generally so very high, and their stems also having a great rake forward.*
+ By the extreme breadth, is meant the breadth taken from timber to timber outside, with the thickness of the bottom on each side added; or, which is the same thing, the thickness of the bottom on each side added to the moulded breadth.

[9] Steel, David. 1805. *The Shipwright's Vade-Mecum*. Pages 254-259.

Using the design specifications for the 36 gun frigates from Joshua Humphreys (Table 1[10]), a set of comparative tunnage calculations has been developed (Tables 2 and 3). Note that the actual vessels "as built" differed from these specifications, but for my purposes here that was not important.

Table 1. Dimensions and sizes of materials for building a Frigate of 36 Guns

	Ft	In
Length of the gundeck from rabbet of stem to post	163	7
Length of keel for tonnage allowing 3/5 of beam		
from the rabbet of the stem at the breadth line from		
the point there the 3/5 strikes on the keel to the rabbet of the post	135	
Moulded breadth of beam in the extream part of the ship		
which is at the upper edge of the second wale and 3 ft 5 ¾ inch		
before the thirds of the keel or 94 ft 2 in before the rabbet of the post	40	
Height of the wing transom above the rabbet of the keel	24	
Height of lower deck above rabbet of the keel	19	2
Topside tumbles home amidship at the underpart of the midship		
plank shear or Covering board		3
Height of the lower deck in the side above the rabbet at ¤	15	7
Plank on lower decks		3 ½
Height between gundeck and lower deck	6	
Gun Deck Plank		4
Height between decks from gun to upper deck	6	9
Upper deck plank		3
Waist amidships		3
Plank shear or covering board		4 ½

Table 2. Factors used in tunnage calculations for 36-gun Frigate (Dimensions are in decimal Feet).

36-gun frigate	Abbreviation	Dimension
163.58	LGD	Length on Gun Deck from Fore Part of Rabbet
135	K	Length of Keel for Tunnage
146	Kt	Length of Keel to the Touch
39	Bi	Breadth (inside)
40	Bo	Breadth (outside)
15.58	Dh	Depth of Hold
17.58	R	Rake of Stem
24	WT	Height of Wing Transom

[10] Humphreys, Joshua. 1794. "Letter, Humphreys to War Department. Dimensions of the Timber and Planks for the Frigates."

The calculated tunnages (Table 3) serve to illustrate how broad the calculated tunnage can be when the different admeasurement methods are used.

Table 3. Calculated tunnage for 36-gun Frigate.

Factor	Baker 1582	Pett 1650	Sutherland 1711	US Law 1789	Steel 1805
K	154.00	163.58	139.58	139.58	134.58
B	39.00	40.00	40.00	40.00	40.00
D	15.58	20.00	20.00	15.58	20.00
Divisor	100	110	94	95	94
Calculated Tuns	935 & 94/100	1189 & 77/110	1187 & 88/94	915 & 82/95	1145 & 37/94
K = Length of Keel as used to calculate the tunnage B = Beam (maximum breadth) as used to calculate the tunnage D = Depth of Hold as used to calculate the tunnage					

The wide spread in calculated tunnage using these five methods illustrates the challenge in applying tunnage estimates to displacement estimates. In the example above, where the dimensions of a single vessel are used, the tunnage estimate ranges from 1,062 1/49 to 2,193 71/95 – more than double the lowest value. Likewise, the length of keel is a difficult and contrived dimension.

McCusker examined the relationship between "measured" and "registered" tonnage for five Philadelphia merchant ships between 1740 and 1775. He found that the measured tonnage, using the tonnage rule of 1695, was on average 147% of the registered tonnage[11]. Walton expanded this study to include many ships clearing at York River and South Potomac River Virginia during 1725-26. His findings for this larger sample mirrored those of McCusker, averaging 149% greater measured tonnage over registered[12]. These results offer a glimpse, perhaps, into the struggles to understand cargo capacity. If the (LxBxD)/x formula is considered accurate, the registered tonnage used for customs and port fees was dramatically low. However, if the registered tonnage figure is deemed accurate, then the question remains – which better represents the internal cargo capacity (closely related to displacement)?

The challenges and issues around tunnage admeasurement have been discussed for nearly three centuries. In the anonymous *The Sea-Man's Vade Mecum* (1707) is found a contemporary opinion in reference to the calculation of the actual ability of a vessel to carry goods when calculating the tunnage[13].

[11] Colonial Tonnage Measurement, 1967.
[12] Colonial Tonnage Measurements: A Comment, 1967.
[13] Anonymous, *Sea-man's Vade Mecum* pages 127-131.

> *"The Shipwrights have a Custom of measuring at London thus; They multiply the length of the Keel into the breadth of the Ship at the broadest place, taken from outside to outside, and the Product of that by the half Breadth; this 2d Product of the Multiplication they divide by 94, or sometimes 100, and according to that Division, the Quotient thereof is so many Tuns;… But this cannot be the true Ability of the Ship to carry, because two Ships by this Rule, of equal Breadth and Length, shall be of equal Burthen, notwithstanding the fulnes of sharpness of those Vessels, which may differ them very much, or the one Ship may have more Timber than the other in her Building, and so carry less: but the true way of Measure, must be by measuring of the Body and Bulk of the Ship under Water … therefore, I say, the Measure of a Ship is known by measuring her, as a piece of Timber may be measured of the Form, to the draught of the Water, assign'd her, the weight of the same Body of the same Water that the Ship swimmeth in, shall be the exact Weight of the Ship, and all things therein, Loading, Rigging, Victuals included therein: then if the Ship be measured to her light Mark, as she will swim at being launched, the Weight of so much Water being taken or subtracted from the Weight of the Water when she is laden, the Residue shall be the Weight that must load Ability of carrying, called her Burthen. By this means you may know the Weight of the Ship light, and what she will carry to every Foot of Water assigned to her, which can be done by no general Rules in Arithmetick, because of their great Irregularity, according to the differing Forms of Ship.*
>
> *"I shall not need to say any thing more concerning measuring of Ships, for it will be understood by those that have Judgement in the measuring of solid Bodies, the Matter it self being but a Nicety, rather than useful. I only touched it, to shew those that are curious minded, which way they may accomplish their Desires. I shall forbear to give Examples, because it will much increase this Treatise, and augment the Price, which might prove more prejudical to young Men, than advantagious."*

The approach suggested reflects an interest in accurately describing the cargo capacity of the ship, rather than an attempt to understand the displacement. Attempts to describe the cargo capacity have been made since at least the mid 16th century. William Bourne in his 1578 *Treasure for Travaylers*[14] described a practical method to obtain a ship's volume estimate by taking its offsets when on dry ground using measuring rods relative to some suitable reference plane.

> *"And to measure the mould of any ship, the ship must be brought aground. And then begin at the broadest place of the ship in this manner.*
>
> *"First, measure the breadth of the ship from outside to outside, at that very place of the upper edge that the ship swims in deepness into the water. Then that being known, measure the true deepness that the ship swims into the water at that place of*

[14] *Treasure for Travaylers* page XXX

> *the broadest part of the ship. Then that being known, take the true contents of half the breadth of the ship, and then with a rod or pole lay the end of the rod or pole that is just the length of half the breadth of the ship, unto just the half keel in breadth at that place before spoken of, and then with another rod or pole of the just length that the ship swims in deepness into the water, lay the end of that rod or pole at that place that the upper edge of the water touches: and then let both the other ends of the two rods or poles touch just together, and so they will make a square angle. And then measuring or trying between the ship and the two rods or poles as you do in the measuring of superficial flat forms, so shall you know the contents of that part that is within the inside of the ship, by subtracting or taking away of that measure between the two rods or poles with the outside of the ship, since you must consider that it is a square enclosed from the middle of the inside of the ship, unto the deepness that the ship swims in the water, and unto the two rods or poles, and has four square or right angles or corners. And then if you multiply it according unto the breadth of the ship and the deepness that the ship goes into the water as you would do if it were a flat form, then pulling away the contents of that same being doubled that the measure is between the ship's side, and the two rods or poles, then that which remains shall be the true contents of that part which is within the inside of the ship as though it were a flat form. And then look how many feet long it runs in that form and proportion in breadth and roundness of the side, then according unto the length multiply the one by the other, that is to say, the contents of the measure before taken of the inside of the ship, and the length that the mould keeps in one proportion, and then cast the contents thereof. And that being done, do as is rehearsed above, according unto the breadth of the ship in another place: then according to the deepness that the ship swims in the water, and then doing with the two rods or poles as is rehearsed above, and so trying between the ship's side, and the two rods or poles, and casting the contents in all points as is rehearsed above: and thus you must do in as many places and as often as the proportion of the mould alters. And then adding them all together you may see how many feet that the ship contains, if it were all one whole piece of timber, and not hollow within."*

Bourne also suggested the use of scale models to measure the volume displacement. The principle of displacement of ships and how to measure it is clearly established, including the concepts of load marks and deadweight measurement. At much the same time, Mathew Baker was measuring the areas of hull sections. Baker provides many examples in his treatise, often including a prismatic coefficient. Barker[15] describes Baker's approach thusly:

> *"One of the more intriguing aspects of the numerical work in Fragments is the frequent calculation of sectional areas of moulds below the depth by Baker, usually linked with the product breadth x depth, effectively giving a prismatic coefficient. Taken with Bourne's Treasure for Travellers on mensuration of ships lines and waterplanes, from which it is perfectly clear that Bourne and his contemporaries knew how to measure displacement tonnage at any selected draught, either as a*

[15] Barker, Fragments (1985) page 175.

> *paper exercise or with the use of models, it is difficult to avoid the conclusion that Deane's contribution to the principles at least of determining displacement (and thence draught at launching) has been overstated. ... It is at least possible that the incentive for both Baker and Wells was the search for a satisfactory tonnage rule. Baker apparently changed his method about 1582: Wells was heavily involved in a Commission to investigate tonnage rules in 1626."*

During the early 17th century, Phineas Pett, his son and his nephew (both named Peter) built ships which included the desired draught of water in the contracts, and the Peter's each launched ships which, when surveyed, were amazingly close to the draught and freeboard specified prior to launch[16].

While measurement of the volume of water displaced by the ship following launch and equipping is useful, it does not allow the naval architect to incorporate the desired draft into the design of the ship. Measurement of the volume of water displaced is more of a proof of design or verification that a vessel meets the design standard. It is interesting, however, to see the relationship of displacement volume and vessel weight addressed, however briefly, as a "Nicety, rather than useful". A similar approach to determining the difference in planar areas at empty and fully burdened states was described by Hudde in 1652 and is illustrated in Figure 2.

Figure 2. Illustration of the measurement of hull using the methods described by Hudde.[17]

The determination of the actual capacity of a vessel, as opposed to the tunnage calculated for both purchase and customs purposes, provides a more realistic measure of the cargo capacity for a ship. Post launch, the difference in draughts method provided verification that the ship as built met the design specifications. Such post launch methods provided information that was useful in estimating the capacity of similar ships, and also aided the designer and builder in future efforts.

By determining the weight of cargo and stores necessary to lower the ship to the desired LWL a baseline for the future equipping of the ship was established. This baseline, however, was

[16] *The Autobiography of Phineas Pett,* pages xcii-xcv and *Trinity House of Deptford Transactions* pages 135 & 142.
[17] Illustration from van Yk, *De nederlandsche scheeps-bou* page 350.

dynamic – as a ship aged, additional weight to the hull was gained as water was absorbed into the wood and leaked into the bilge, sections were painted or tarred, and adjustments made to the ballast. It was possible utilizing these difference in draughts methods to determine whether the as built ship was able to carry the desired amount of weapons, ammunition, crew and provisions for the intended duty. These post launch measurements, though, did not demonstrate an ability to accurately determine pre-construction the capacity as the actual loading was done to ensure that the ship did not exceed the design LWL.

During the 17th and 18th centuries, additional progress was made in determining the cargo capacity. In his *Doctrine of Naval Architecture*, Deane describes two methods for determining the volumetric displacement (not as a measure of displacement, but rather as a means to determine the additional weight which would bring a ship to the desired LWL)[18]. Deane used both a method of triangles and squares to approximate the hull, as well as a semicircle inscribed to approximate the shape of the hull. Of particular note was that Deane's methods were pre-construction, based on the plans for the ship, not post construction. His approach, however, was still a version of the "Difference in Draughts" method previously described.

Bibliography

Anonymous. 1707. *The Sea-Man's Vade Mecum: Containing the Most Necessary Things for Qualifying Seamen of All Ranks*. Printed and Sold by James Woodward behind the Royal-Exchange,. http://www.bruzelius.info/Nautica/Bibliography/Vademecum%281707%29.html.

Barker, Richard. 1985. "Fragments from The Pepysian Library." *Revista Da Universidade de Coimbra* XXXII: 161–78. http://home.clara.net/rabarker/Fragments83txt.htm.

Bourne, William. 1578. *A Booke Called the Treasure for Traveilers : Devided into Five Bookes or Partes, Contaynyng Very Necessary Matters, for All Sortes of Travailers, Eyther by Sea or by Lande*. Imprinted at London : [By Thomas Dawson] for Thomas Woodcocke. http://archive.org/details/bookecalledtreas00bour.

Deane, Sir Anthony. 1981. *Deane's Doctrine of Naval Architecture, 1670*. Edited by Brian Lavery. London: Conway Maritime Press.

Humphreys, Joshua. 1794. "Letter, Humphreys to War Department. Dimensions of the Timber and Planks for the Frigates." Letterbook Copy. RG45. National Archives and Records Administration. http://wardepartmentpapers.org/document.php?id=42218.

McCusker, John J. 1967. "Colonial Tonnage Measurement: Five Philadelphia Merchant Ships as a Sample." *The Journal of Economic History* 27 (1): 82–91. http://www.jstor.org/stable/2115449 .

[18] Deane, *Doctrine of Naval Architecture* pagexxx.

Moorsom, George. 1853. *A Brief Review and Analyses of the Laws for the Admeasurement of Tonnage ... Also of a Mode Proposed for the More Correct Admeasurement of Vessels*. 2nd ed. Wm. H. Allen and Co. https://books.google.com/books?id=jadWAAAAcAAJ.

Oppenheim, Michael. 1896. *A History of the Administration of the Royal Navy and of Merchant Shipping in Relation to the Navy, from MDIX to MDCLX, with an Introduction Treating of the Preceding Period*. London, New York, J. Lane. http://archive.org/details/historyofadminis00oppe.

Pett, Phineas. 1918. *The Autobiography of Phineas Pett*. Edited by W. G. Perrin. [London]: Printed for the Navy records society. http://archive.org/details/autobiographyofp00pettuoft.

Salisbury, William. 1966a. “Early Tonnage Measurement in England.” *The Mariner’s Mirror* 52 (1): 41–51. doi:10.1080/00253359.1966.10659309.

———. 1966b. “Early Tonnage Measurement in England: Part III. H.M. Customs, and Statutory Rules.” *The Mariner’s Mirror* 52 (4): 329–40. doi:10.1080/00253359.1966.10659347.

———. 1966c. “Rules for Ships Built For, and Hired By, the Navy.” *The Mariner’s Mirror* 52 (2): 173–80. doi:10.1080/00253359.1966.10659324.

———. 1967. “Early Tonnage Measurement in England: IV. Rules Used by Shipwrights, and Merchants.” *The Mariner’s Mirror* 53 (3): 251–64. doi:10.1080/00253359.1967.10659390.

———. 1968. “Early Tonnage Measurement in England: Part V. Colliers, Deadweight, and Displacement Tonnage.” *The Mariner’s Mirror* 54 (1): 69–76. doi:10.1080/00253359.1968.10659419.

Steel, David. 1805. *The Shipwright’s Vade-Mecum: A Clear and Familiar Introduction to the Principles and Practice of Ship-Building…* London: P. Steel. http://archive.org/details/shipwrightsvade00steegoog.

Sutherland, William. 1711. *The Ship-Builders Assistant: Or, Some Essays towards Compleating the Art of Marine Architecture*. London: printed for Mount, Bell, and Smith. http://echo.mpiwg-berlin.mpg.de/MPIWG:12RWTM5U.

Walton, Gary M. 1967. “Colonial Tonnage Measurements: A Comment.” *The Journal of Economic History* 27 (3): 392–97. http://www.jstor.org/stable/2116033.

Yk (Ijk), Cornelis van. 1697. *De Nederlandsche Scheeps-Bouw-Konst Open Gestelt: Vertoonende Naar Wat Regel, of Evenredenheyd, in Nederland Meest Alle Scheepen Werden Gebouwd : Mitsgaders Masten, Zeylen, Ankers, En Touwen, Enz. Daar Aan Gepast : Soo Suit de Schriften van Ouder, Als Jonger Bouw-Meesters, Als Ook by Eygen Ondervindinge, Tot Nut van Alle Jonge Bouw-Meesters En Knechten, Als Ook Uitreeders En Liefhebbers van Scheepen*. https://archive.org/details/gri_33125012921124.