



Section B

SHIPS

The ship has shaped the world we know today, with the rise and fall of maritime empires, forced and voluntary migration creating new societies in the Americas and Australasia, and world patterns of trade. Locally, the fishing industry often creates an individualistic culture. The ship is still far more important than most people realise, with 95% of world trade travelling by sea. For most people the ship is at the centre of maritime history (though other areas such as seaside holidays or flood defence should not be ignored).

It is not necessary for either the curator or the museum visitor to understand the technology of the ship in full, but they should be aware of what ships could do at any period in history. The Atlantic cultures were shaped by the circular wind pattern which allows travel to west and east. Fishing activities often depended on local wind patterns. The development of the steamship opened up many new areas, but its demand for coal created different problems. Today there are concerns about the effect of great ships on the environment.

Since the mid-16th century practically all ships have been designed on paper using a plan, and this is increasingly true of larger boats as well. Many ships plans are rather technical documents, though it is hoped that the articles here will make them more accessible to curators. Plans often come from local shipbuilders and represent their history, as well as the skill of the draughtsmen who produced them, and the workers who turned them into reality. They give the most accurate indication of the exact shape and fitting of a ship, and as such they are invaluable historic sources. They can only be used sparingly as display items, due to their size and environmental requirements, but deck plans are not too different from floor plans of houses and might give a good indication of life on board a ship, such as a major warship or a great liner.

Models are perhaps the best way of representing the ship, although care needs to be taken with interpretation – the old-fashioned image of a maritime museum is a room stuffed with ship models with very little effort to interpret them. It is better if they can be arranged to tell the story of the development of ships in general or of a particular type, or illustrate the uses and art of models as in the current gallery at Chatham Historic Dockyard, or alternatively individual models can form part of a wider display.

Preserving actual ships is one of the ultimate aims of maritime heritage, but it is a major task which is not to be undertaken lightly, as Matthew Tanner makes clear in his article. There are major successes, including his *Great Britain*, but often they are only achieved after years of scepticism or apathy from the authorities. This is one example of a project centred on a single ship. Other institutions, such as the National Museum of the Royal Navy and the Merseyside Maritime Museum, look after several ships as part of a wider range of activities.

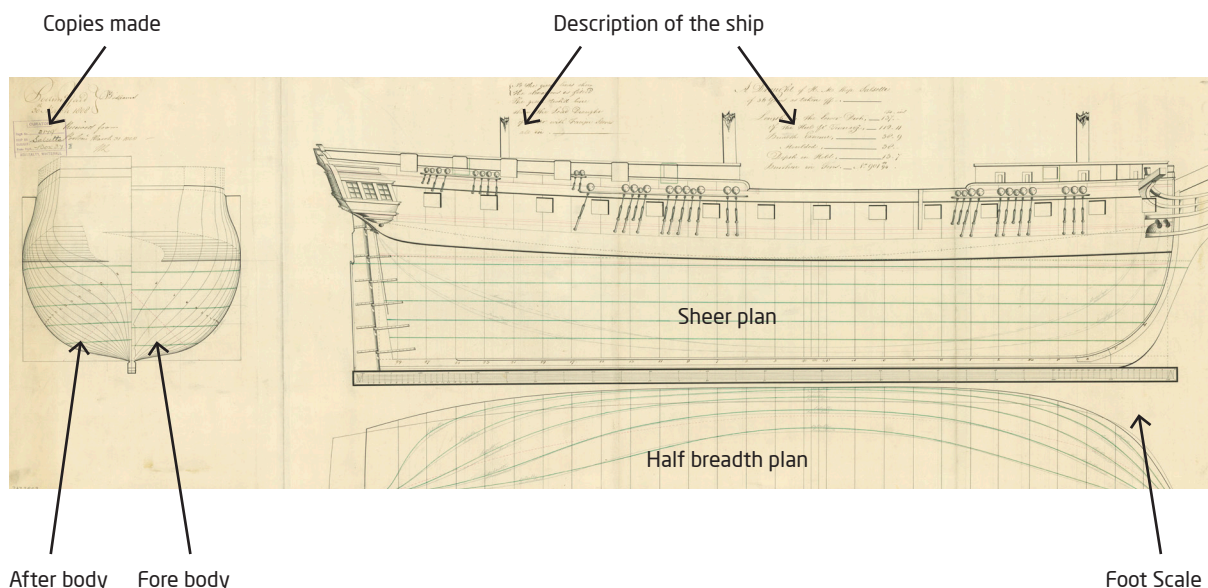
1 SAILING SHIP PLANS

BY BRIAN LAVERY, CURATOR EMERITUS,
NATIONAL MARITIME MUSEUM

Original plans of sailing ships are very rare, especially merchant ships. By far the best collection is in the National Maritime Museum, but that is mainly of warships – nearly every British warship since about 1715, plus many of those captured from enemies.

This is offered as a guide to interpreting these plans.

THE DRAUGHT

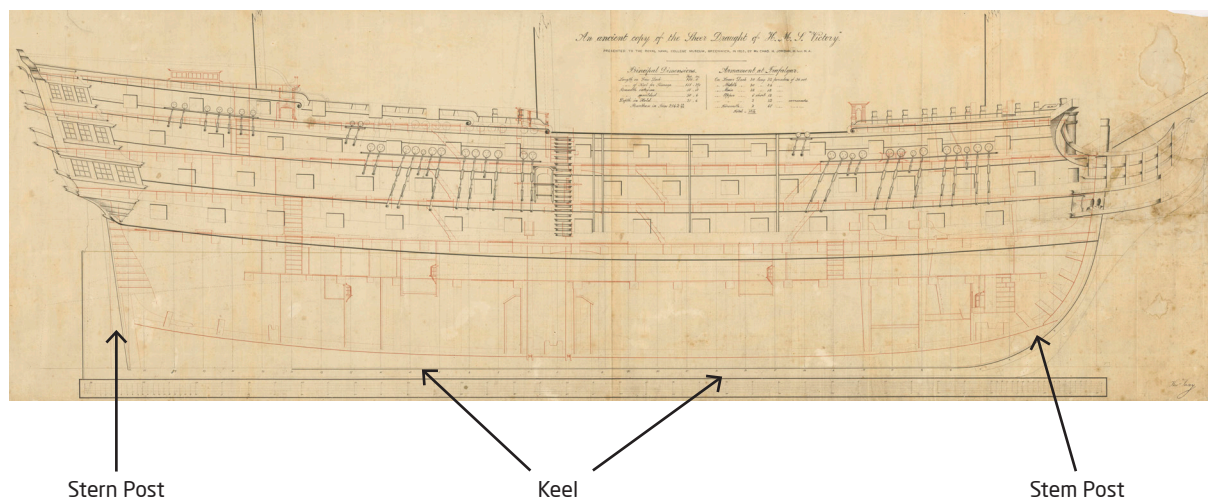


Salsette (1808), a 36-gun frigate built at Bombay Dockyard

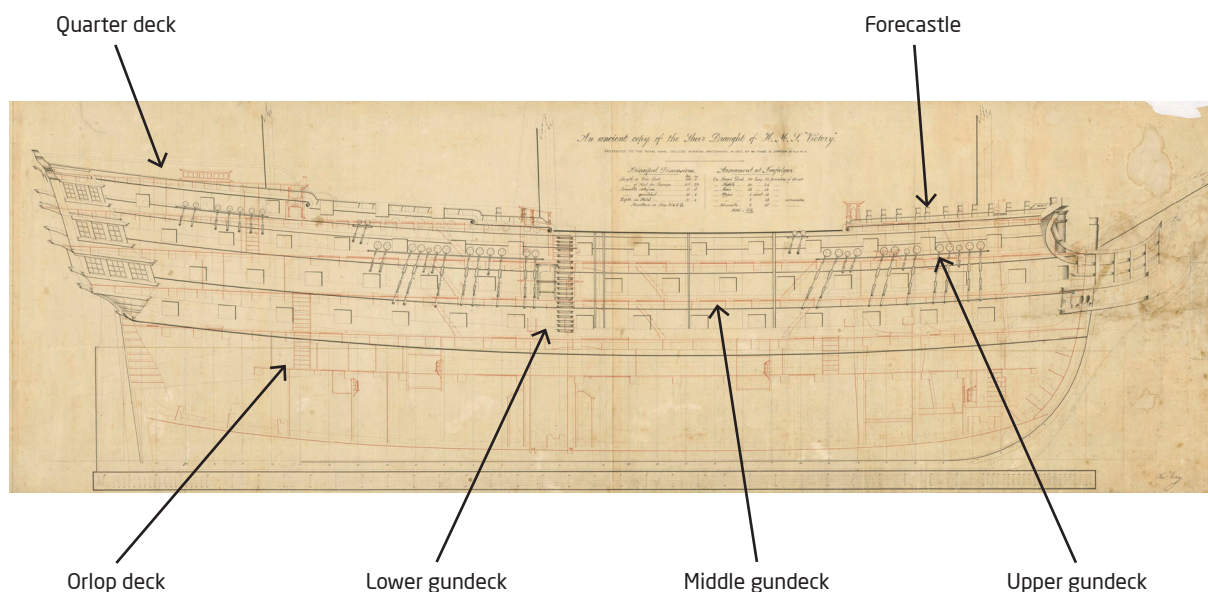
ZAZ2863 (Repro ID.J5788) Admiralty Sailing Navy Collection © National Maritime Museum, Greenwich, London

Early in the 18th century the plan is often on a single sheet, which includes four views of the ship. These were nearly always drawn to a scale of 4 feet to the inch or 1:48 and often include a scale under the keel of the ship. The sheer draught is a side view, and alongside it are the after body and fore body plan, both including cross-sections to show the complex shape of the ship. Underneath is the half breadth plan which shows hypothetical waterlines at which the ship would float if loaded in a certain way. They are used to ‘fair’ the lines, to show that the water would run smoothly as the ship passed through the water. At the top of the draught is a description of the ship, including dimensions, guns to be carried etc. The name is not always given, as it might not have been chosen at that stage in the design. On the top left there is sometimes a list of copies made and sent out to shipyards to build similar ships of the class.

FEATURES OF THE SHEER PLAN



The first parts to be drawn were the keel, which was long and flat, the curved stem post which formed the basic shape of the bow and head, and the straight stern post from which the rudder was hung.



The square ports for the guns are drawn on the sheer plan in a warship or armed merchant ship. The decks are sometimes drawn in red on the same plan, as shown here, or on a separate plan. A warship is defined by the number of full decks of guns. The largest were three-deckers as shown here, two-deckers were the standard heavy warships or ships of the line, while frigates also had two decks with the lower one unarmed, and sloops had only a single deck. Every ship except the smallest had a quarterdeck aft running about half the length of the ship and a forecastle forward, which was smaller still. A ship usually had an orlop deck under the gundecks, below the main waterline.

Both images above: *Victory* (1765), a 104-gun first rate built at Chatham Dockyard
ZAZ0121 (Repro ID J1850), Admiralty Sailing Navy Collection © National Maritime Museum, Greenwich, London

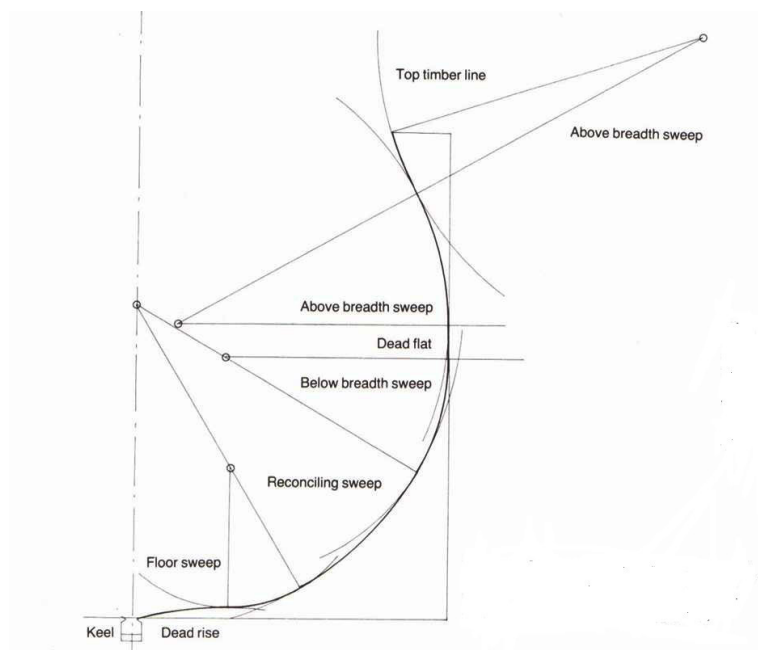


Image © Brian Lavery

THE MIDSHIP SECTION

The next task of the designer was to draw the midship section, a cross-section of the ship near its centre and at its widest point. For economy he usually only drew one half of it. It was made up of a series of arcs of circles (known as sweeps) joined by tangents as shown. It formed the characteristic 'tulip bulb' shape. The midship section would form the basis for the rest of the hull shape.

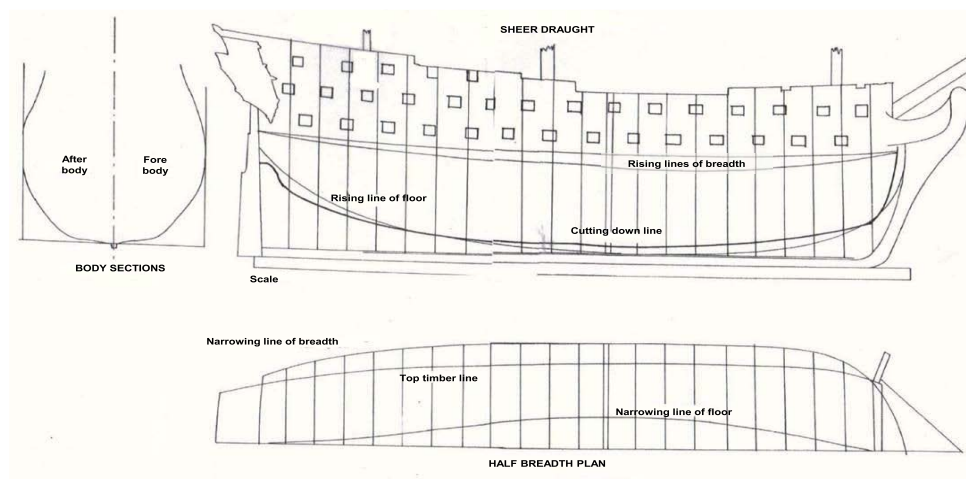


Image © Brian Lavery

CONSTRUCTION LINES

The designer then used various construction lines to form the shape of the body as it approached the bow and stern from the midship section. These are usually shown on the plans, though they are not to be found on the finished ship. The floor sweeps in the lower part of the hull were usually of the same diameter, while the breadth sweeps reduced in diameter towards the bow and stern. Since the floor sweeps were progressively raised above the keel, it was necessary to use a straight line or curve to join it to the keel.

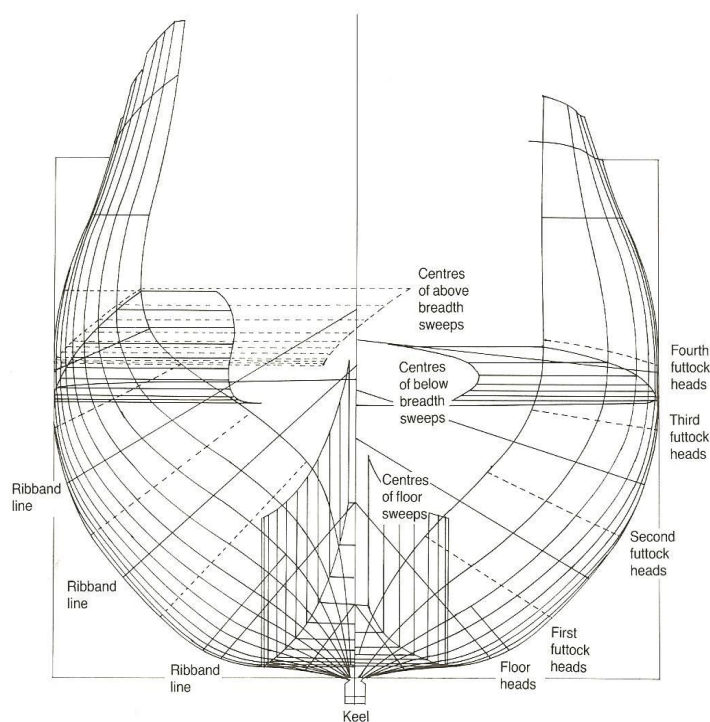
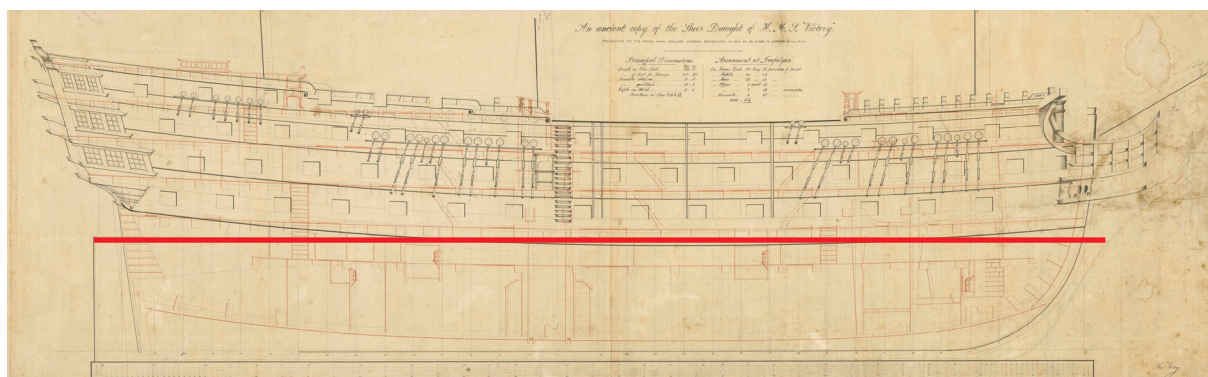


Image © Brian Lavery

THE BODY PLAN

The finished body plan is shown here. The floor and breadth sweeps for each frame are represented by vertical and horizontal lines. The diagonal lines shown are for the construction and structure of the ship. The ribband lines are where pieces of wood will be fitted to hold the frames at the correct spacing until the planks are fitted. The floor and futtock heads represent the places where pieces of timber are joined to form each frame.

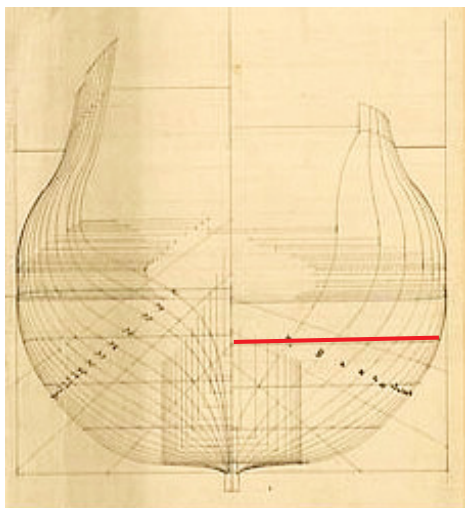
FAIRING



Victory (1765), a 104-gun first rate built at Chatham Dockyard

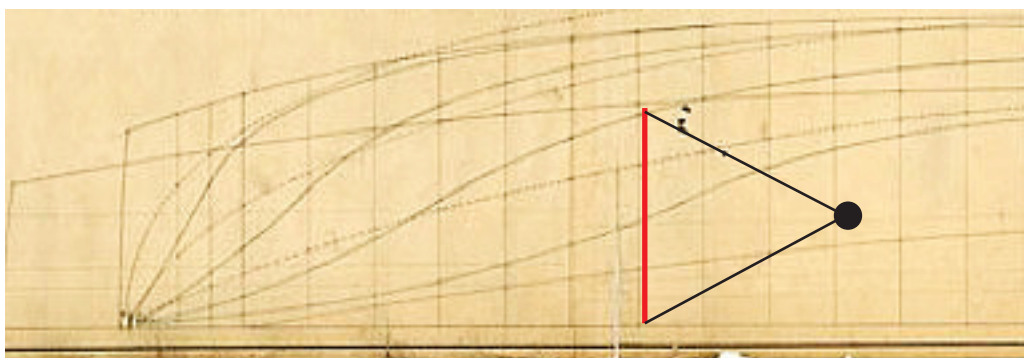
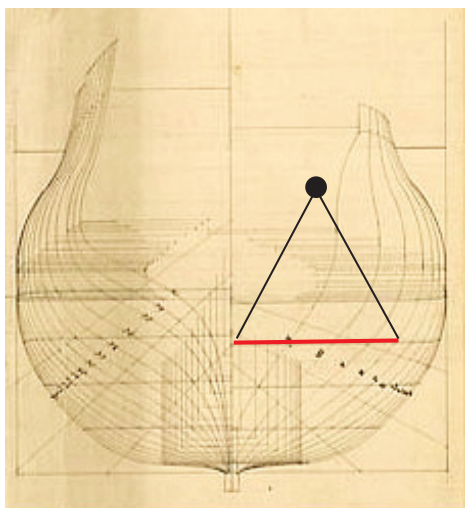
ZAZ0121 (Repro ID J1850) Admiralty Sailing Navy Collection © National Maritime Museum, Greenwich, London

The hypothetical waterlines are drawn on the sheer plan as in the example shown.



Dragon (1760), a 74-gun third rate built at Deptford Dockyard

Hilhouse Collection, HIL0171 (Repro ID J8287), Admiralty Sailing Navy Collection © National Maritime Museum, Greenwich, London

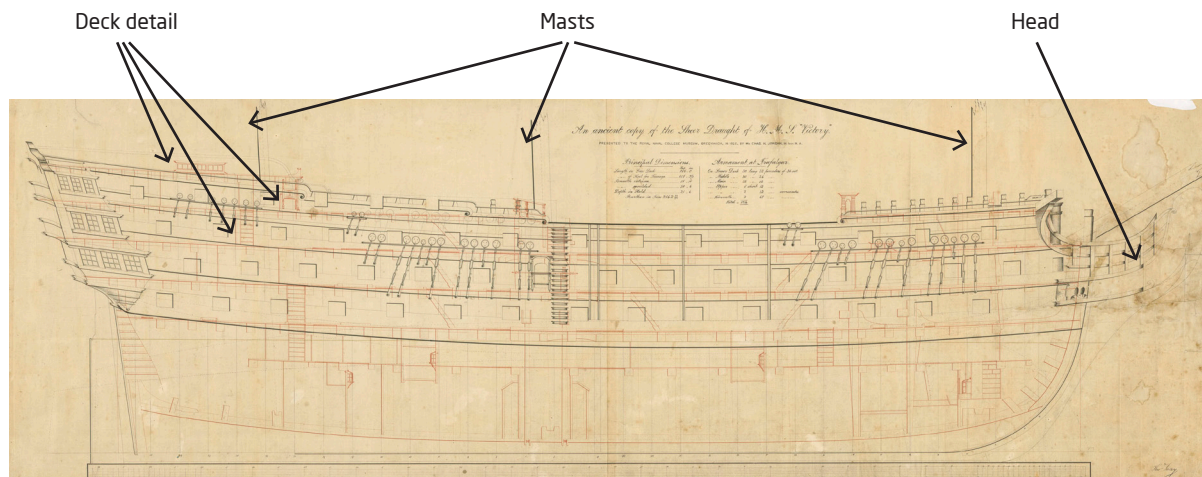


Both images above are of Dragon (1760), a 74-gun third rate built at Deptford Dockyard

Hilhouse Collection HIL0171 (Repro ID J8287), Admiralty Sailing Navy Collection © National Maritime Museum, Greenwich, London

The designer measures the width of each waterline at each individual frame then transfers it to the body plan until it is completed. This gives a good idea of how well the hull is 'faired'. Later in the 18th century, vertical and diagonal lines were used to test the fairing further.

OTHER FEATURES

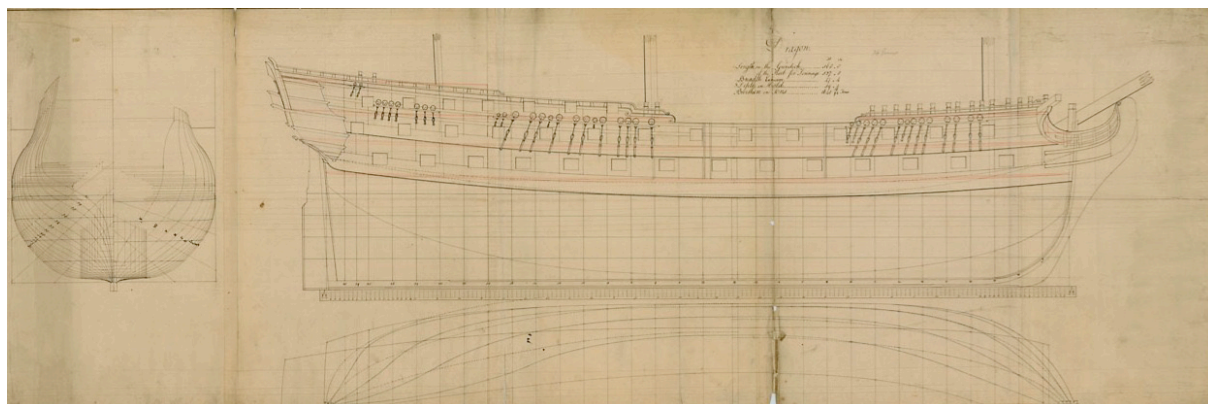


Victory (1765), a 104-gun first rate built at Chatham Dockyard

ZAZ0121 (Repro ID J1850) Admiralty Sailing Navy Collection © National Maritime Museum, Greenwich, London

Various other features were often added to the plan in different coloured ink.

THE COMPLETED PLAN



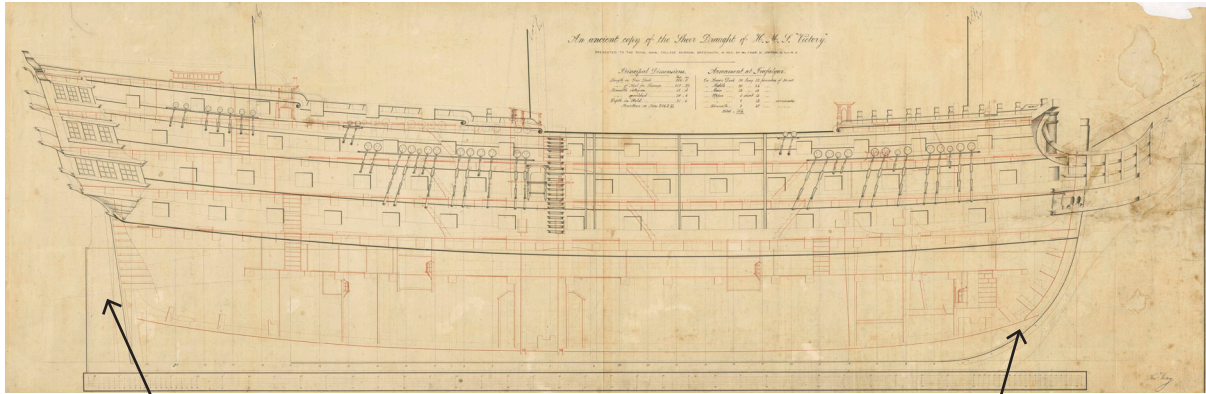
Dragon (1760), a 74-gun third rate built at Deptford Dockyard

Hilhouse Collection HIL0171 (Repro ID J8287), Admiralty Sailing Navy Collection © National Maritime Museum, Greenwich, London

This shows a two-decker ship of the line.

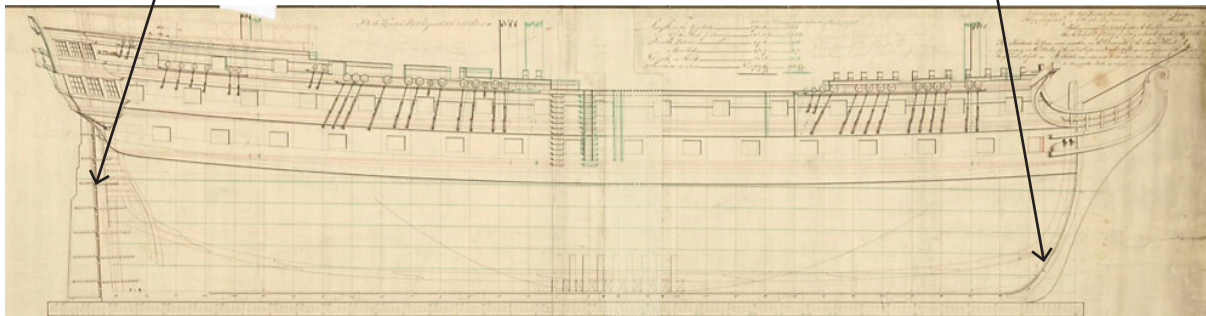
BRITISH AND FRENCH DESIGN

The British captured many French ships during numerous wars from 1789 to 1815, and often took the lines off them to study and sometimes copy the design. This highlighted the different design practices of the two nations, as shown here by the British *Victory* of 1765 and the French *Invincible* of 1744.



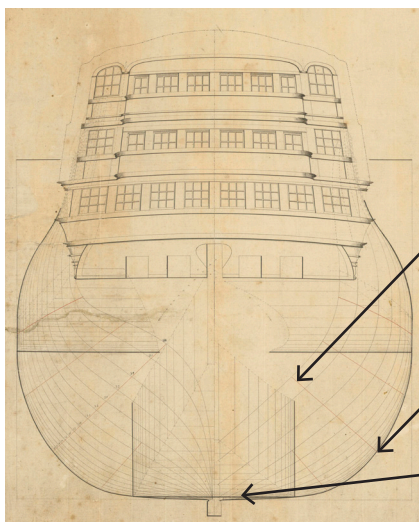
More vertical stern post on French ship (below)

More rounded stem on *Victory* (above)



Top image: *Victory* (1765), as before. Above image: *Invincible* (1744)

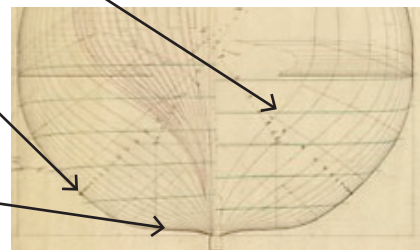
Both images © National Maritime Museum, Greenwich, London



Shape of the bow sections is straighter on British ship (left)

Sharper 'turn of the bilge' on French (right) ship

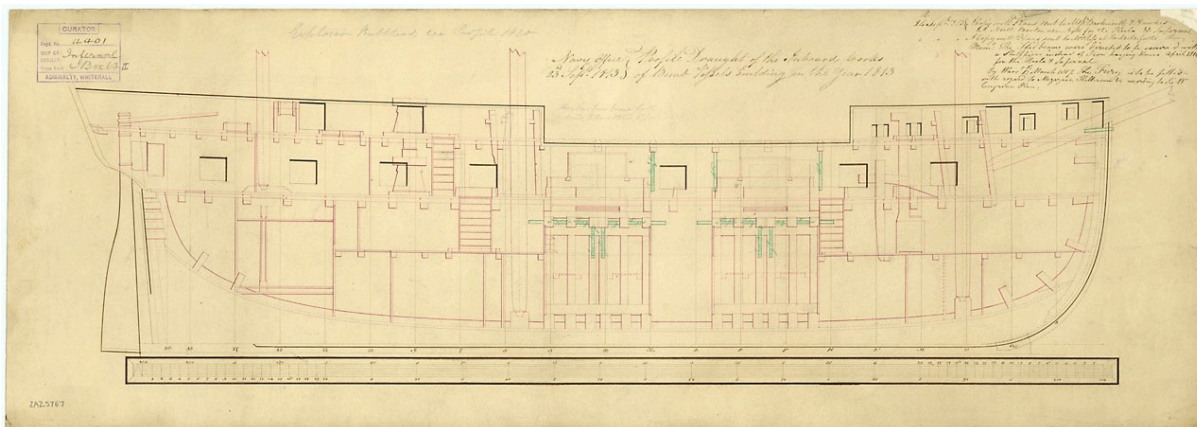
Flat floor on British ship, curved on French



Images above © National Maritime Museum, Greenwich, London

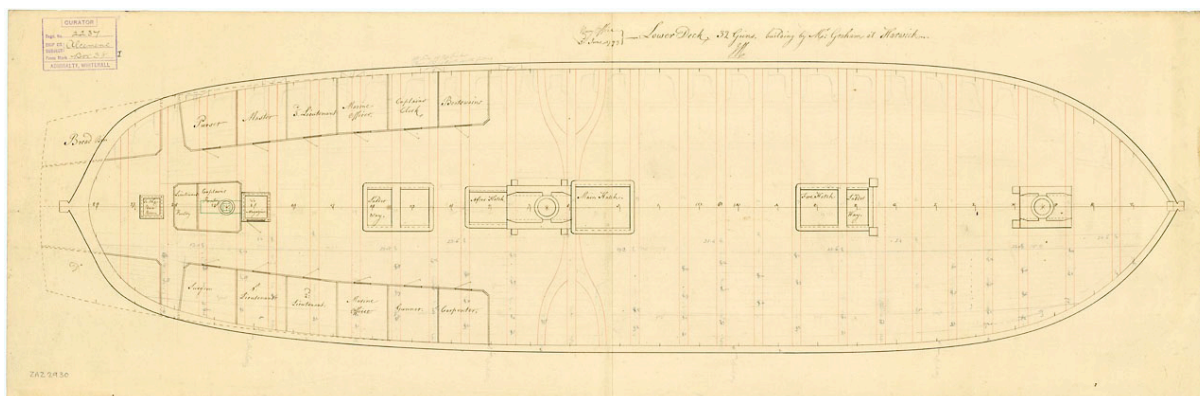
OTHER PLANS

As the 18th century progressed, more plans were produced for each ship, for example:



The longitudinal section or inboard profile of a bomb vessel of the Infernal class, showing the interior of the ship, 1813. Infernal (1815) and her class, all bomb vessels

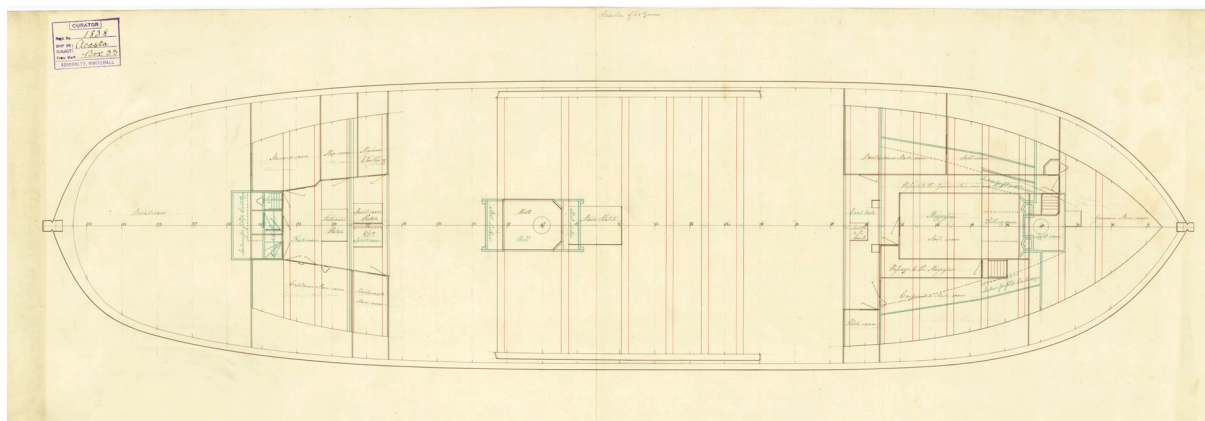
ZAZ5767 (Repro ID J7571), Admiralty Sailing Navy Collection © National Maritime Museum, Greenwich, London



The orlop deck of the frigate Alcmene of 1793

Alcmene (1794), a 32-gun frigate built at Harwich by Mr Graham. Admiralty Sailing Navy Collection

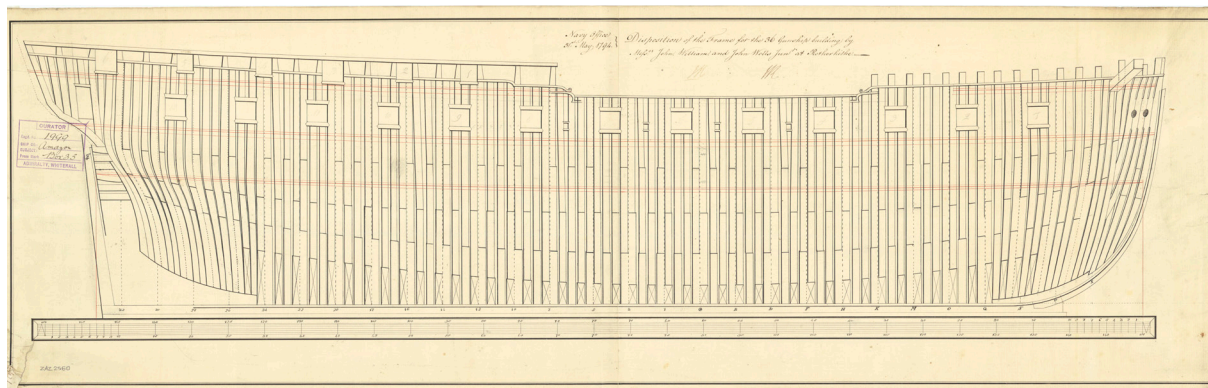
ZAZ2930 (Repro ID J5845) © National Maritime Museum, Greenwich, London



The lower deck of the frigate Acasta of 1797

Acasta (1797), a 40-gun frigate built at Rotherhithe by Mr Randall

ZAZ2304 (Repro ID J5498), Admiralty Sailing Navy Collection, © National Maritime Museum, Greenwich, London



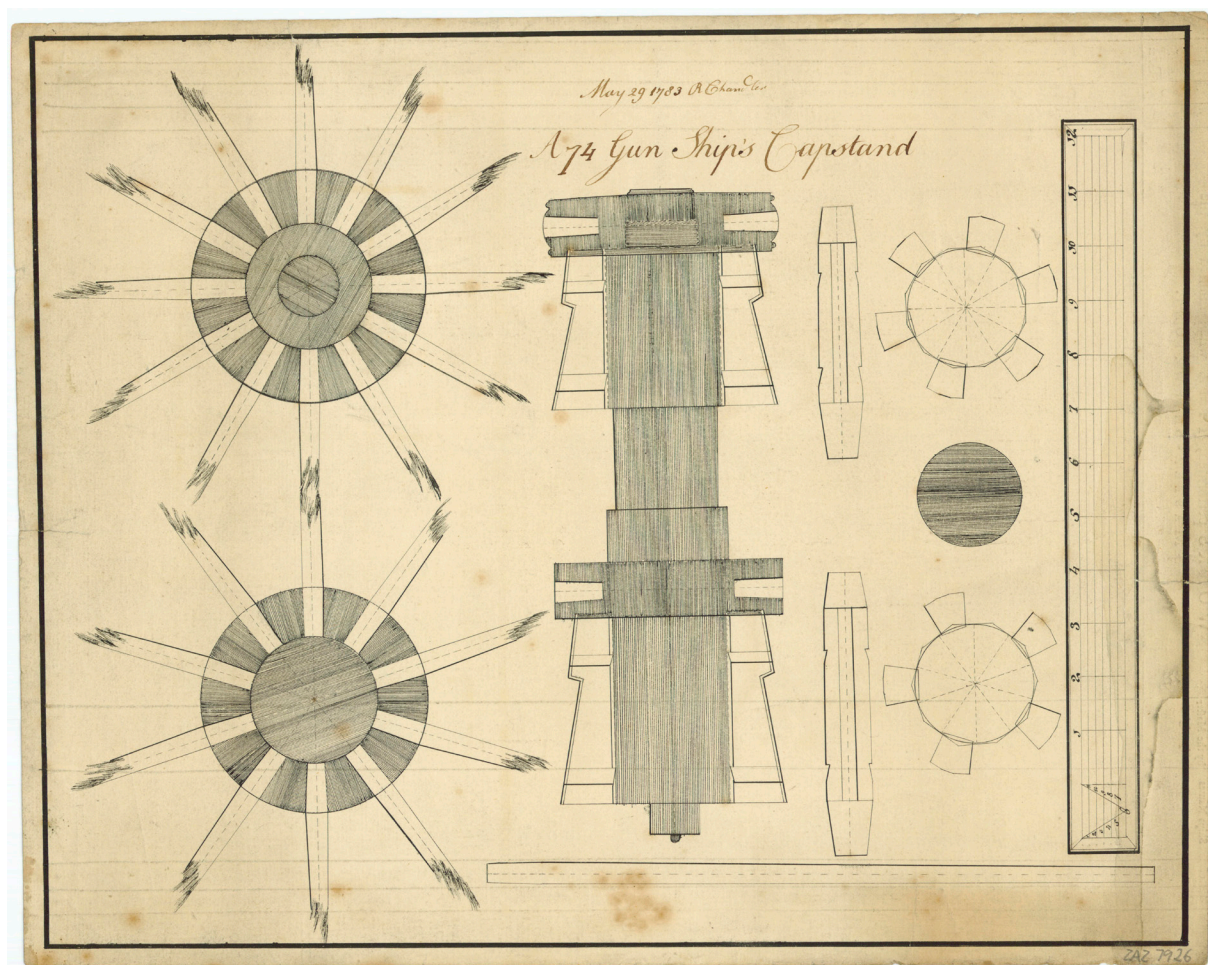
Framing plans were drawn for many ships.

Amazon (1795), a 36-gun frigate built at Deptford by Mr Wells

ZAZ2560 (Repro ID J5264), Admiralty Sailing Navy Collection, © National Maritime Museum, Greenwich, London

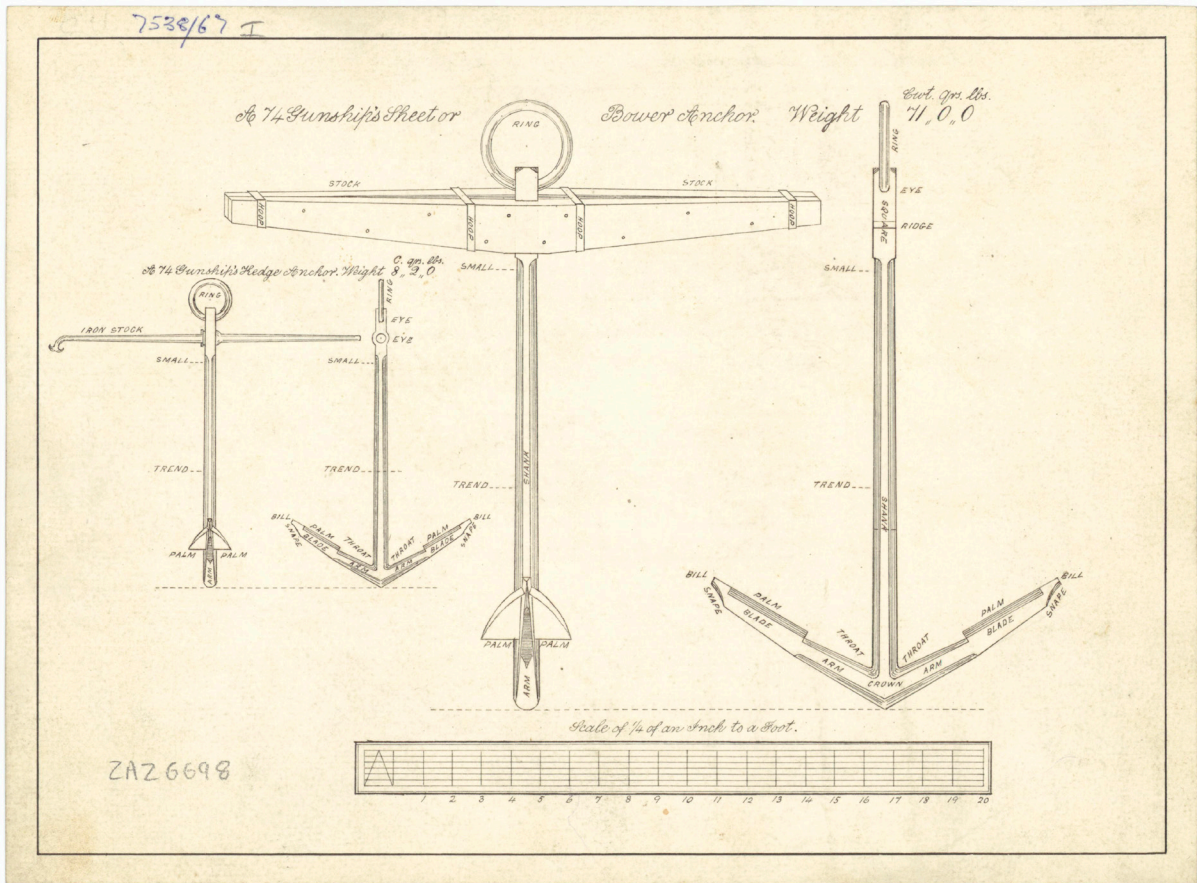
FITTINGS

Many examples of fitting details are often to be found, though not always for specific ships.



A capstan of 1783 for 74-gun two-decker, third rates

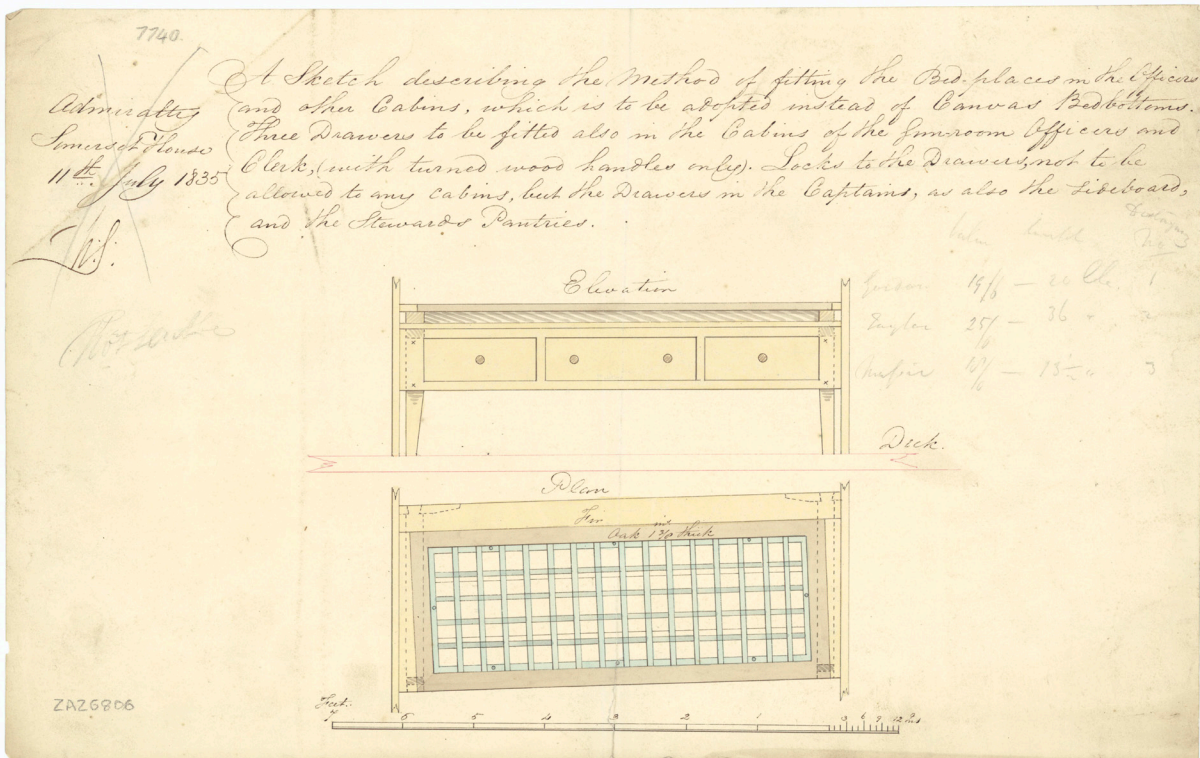
ZAZ7926 (Repro ID J7568), Admiralty Sailing Navy Collection © National Maritime Museum, Greenwich, London



A full set of anchors for a 74-gun ship

A sheet or bower anchor for 74-gun two-decker, third rates

ZAZ6698 (Repro ID Jo418), Admiralty Sailing Navy Collection © National Maritime Museum, Greenwich, London



Officers' bunks, 1835

The bed places in officers' cabins

ZAZ6806 (Repro ID Jo609) Admiralty Sailing Navy Collection © National Maritime Museum, Greenwich, London

BIBLIOGRAPHY

Sir Wescott Abell, *The Shipwright's Trade*, 1948, reprinted 1981

William Burney, *New Universal Dictionary of the Marine*, 1815, reprinted 1970

Edmund Bushnell, *The Compleat Shipwright*, 1664

Brian Lavery, *Deane's Doctrine of Naval Architecture*, London, 1981

Brian Lavery, *Ship of the Line*, vol 2, *Design, Construction and Fittings*, London, 1984

David Lyon, *The Sailing Navy List*, London, 1993

Mungo Murray, *A Treatise on Shipbuilding and Navigation*, 1750

Marmaduke Stalkaart, *Naval Architecture*, 1781

William Sutherland, *The Shipbuilder's Assistant*, 1711 and *Shipbuilding Unveiled*, 1717

2 SHIP PLANS AND TECHNICAL RECORDS

BY FRED M. WALKER, NAVAL ARCHITECT AND
FORMERLY OF NATIONAL MARITIME MUSEUM

BACKGROUND

Technical drawings are the most significant of all the records describing ships, boats, and marine vehicles. Well-executed designs, thoughtfully arranged drawings, and clear unambiguous calculations encapsulate the technical qualities of a ship in a form which is everlasting and requires little storage space.

The earliest ship plans as we now know them (that is accurate drawings made to a defined scale) are from the closing years of the 17th century. Examples are found in the Scheepvaartmuseum, Amsterdam and the National Maritime Museum, Greenwich. Our knowledge of ship construction prior to this depends on the wealth of information from archaeology, and on the detective work of researchers using old reports, documents, images, graffiti and countless thousands of well executed marine oil paintings.

The technical skill of ship drawing developed in parallel with the growth of maritime technology. From the late 17th century, naval architecture theory has been evaluated by empirical observation and careful scientific experimentation. Such fundamental research was the catalyst for the development of drawing board conventions which enable us to describe the complex shapes and the characteristics of ships in two dimensions. As always, hostilities accelerated scientific advance, and the building of warships at the cutting edge of technology ensured that ship drawing became a sophisticated art and science.

As naval warfare reached a peak in the 18th and 19th centuries, the ‘quality’ of ships became a matter of concern to all governments and it was normal for captured ships to be inspected and measured and their lines and layout recorded for evaluation and ultimately for incorporation into new construction. An example of this is the *Leda* Class of sailing frigates whose design was ‘supplied under duress’ to the Royal Navy by the French. Two examples of this are afloat today, HMS *Trincomalee* (1817) in Hartlepool and the Frigate *Unicorn* (1824) berthed in Dundee.

In the merchant sector, few ships were built with plans and their construction was ‘by eye’ but also to the strict traditions of the part of the world in which they were built. Examples of this continue to this day in South East Asia. There was little scientific about this and the lack of knowledge and understanding of the principles of naval architecture was reflected in the massive losses of ships at sea in the 18th and 19th centuries.

In 1819, at the request of the Forth and Clyde Canal Company, an iron hull was constructed at Coatbridge near Glasgow. This 20-metre canal passage boat *Vulcan* became the first properly constructed “ship shape” iron vessel in the world. Overnight, the shipyards had to consider precision engineering, as building a hull in iron (or steel) requires accurate templates and costly prefabricated parts must fit exactly. This problem of accuracy was solved by shipyards setting up drawing offices entrusted with the task of designing each and every part of the ship, planning production and ordering all materials.

INTELLECTUAL PROPERTY RIGHTS

Ship design is a significant cost in the building of a ship. Plans and associated documents represent a serious investment and must be considered first as intellectual property, but secondly (subject to any restraints in English or Scottish Law) as a resource available to the public as an unique part of our heritage.

CONVENTIONS

In the past two hundred years, conventions for the drawing of ship plans have become standard and international. It is unprofessional to disregard these conventions, which are designed to avoid costly mistakes in ship production. All ships are drawn 'steaming' to the right hand side of the plan (on an external profile, the starboard side in view). All plans large or small are similar ensuring that office and workshop work to the same arrangement.

In a Lines Plan there are three views; the Waterplanes, the Bow and Buttock Lines and the Body Plan. Purists may notice that these are not drawn according to standard projections, but it has become a convention that waterplanes are drawn concave to the draughtsman, making the fairing of lines easier and more accurate. In body plans, the forward sections are on the right and after sections on the left.

For measurement, calculation etc, ship designs have ordinates or 'stations' throughout. Current merchant practice is for the ship to have 11 stations dividing the vessel into ten sections of equal length, with the after one or Aft Perpendicular numbered 0 and the Forward Perpendicular numbered 10. Similarly the frames ('ribs' of the ship) are numbered from the aft end, allowing each position in the ship to be defined by the frame number (port or starboard). In warships, the numbering convention is reversed.

SCALE

Throughout history, differing styles and units of measurement have been used, and many European countries have had minor variations on the actual definition of the imperial foot. Fortunately most plans use either the metric system or the (British) imperial foot. The choice of scale reflects the size of paper on which the plan is drawn and also the amount of detail required. There are several regularly used scales, and whether metric or imperial, give nearly the same overall dimensions. They include:

1 : 10	metric
1 : 12	imperial otherwise known as one inch to the foot
1 : 20	metric
1 : 24	imperial otherwise known as $\frac{3}{4}$ " to the foot
1 : 25	metric
1 : 48	imperial otherwise known as $\frac{1}{4}$ " to the foot
1 : 50	metric
1 : 96	imperial otherwise known as $\frac{1}{8}$ " to the foot
1 : 100	metric

Prior to metrication, marine engine builders used two unusual scales:

1 : 16	imperial or $\frac{3}{4}$ " to the foot
1 : 32	imperial or $\frac{3}{8}$ " to the foot

PLAN SIZES

From the late 19th century until the 1960s most ship plans were drawn on long rolls of paper or linen, sometimes several metres in length. A deck plan of the passenger liner *Aquitania* of 1913 (which was 870 feet long) drawn at 1/4" to the foot or 1: 48 would have been over 18 feet long, that is 5.5 metres although it is likely to have been drawn in two smaller parts. In consequence, shipyard offices were equipped with pigeonhole racking as most plans were issued in roll form.

In the 1950s and 1960s efforts were made to limit plan size and standardisation was introduced. This rationalisation has come so far in recent years that several naval architecture companies make a virtue of keeping plans within the A0 format which enables easy folding and simple filing. The author's company previously completed design work for a 500 tonne, three-masted barque using A3 sheets throughout measuring 420 by 297 mm, landscape. In small plans, the thickness of a pencil line is significant, this can be overcome by ensuring that all dimensions are calculated and clearly exhibited.

PLAN MATERIALS

Early plans were on handmade paper and vellum. The latter plans are important, and conservation is a matter of concern. Over the years materials have simplified:

Cartridge Paper or hot pressed handmade paper is long lasting, remains dimensionally stable and is pleasant to handle. These plans may last for centuries if stored in temperate conditions.

Tracing Paper is less stable and once embrittled can shatter like glass. It should never be folded, but placed in rolls.

Tracing Linen is in most ship plan collections. It is made of linen woven to an incredibly thin degree and coated with a proprietary starch material making it smooth and translucent. Most ship plans on linen are drawn in Indian ink allowing them to be reproduced on dye-line processes. Linen has a long life and benefits from the rolling and unrolling for reprographic machines as this ensures good ventilation. Dampness is the great enemy of linen tracings.

Tracing Film is an unknown quantity, so it may be prudent to make security copies of really important plans. Film has one great benefit; it accepts fine ball-point nib pens, making plan drawing both easier and cheaper.

Blue Prints, Dye-Lines, and other Secondary Copies. Often these are the largest constituent part of any plan collection and come rolled, folded, boxed, and in other conditions. Many are working plans from the workshop and can be dirty and damaged, but this should not relegate them to the recycling depot, provided they supply unique and vital heritage information.

Finally, a warning. Handling plans is difficult:

- Large rolls of plans are heavy. Consider storage and heights of shelving.
- Paper is hard and plan edges present vicious tools for cutting hands.

PLAN STORAGE

Most plans up to the 1970s and even later are held in large heavy rolls, which in turn are kept in pigeonhole storage or in custom built plan cases. The National Maritime Museum at Greenwich has standard plan cases made of heavy-duty acid free board with typical dimensions of 1.20 x 0.18 x 0.18 metres. Such systems take care of the vast bulk of plans in the large national collections.

In the immediate post- World War Two period many shipyards attempted to rationalise their plan-

drawing systems and introduced standard drawing sizes with systems for hanging them in custom-built cabinets.

The introduction of metric plan sizes has enabled shipyards, naval architects, and others to hold plans in books and folders based on the A2 and A3 sizes.

PLANS REQUIRED FOR THE CONSTRUCTION OF A SHIP

In theory it is possible to build a ship using a couple of dozen scale drawings, but in reality the total number may run into hundreds. It is always an unhappy experience having to ‘weed’ ship plans as each and every one deserves serious consideration, but the following plans (drawn from differing ship types) may be regarded as representative drawings in the event of a curator or custodian being forced to reduce storage capacity:

- | | |
|---------------------------------------|--|
| • Preliminary Design | Drawings prepared for contract negotiation |
| • General Arrangement | Plans of each deck and principle area |
| • Lines and Body Plan | |
| • Offsets | An exhaustive table of all hull dimensions |
| • Midship Section | |
| • Profile of Bow and Contour of Stern | |
| • Structural Profile | |
| • Shell Expansion | The shape of the hull once ‘ironed’ out flat |
| • Sails and Rigging | |
| • Stern frame | |
| • Rudder | |
| • Machinery Layout | |
| • Propeller or Propulsors | |
| • Capacity Plan | Details of all cargo capacity |
| • Paint Lines | |
| • Docking Plan | Information to enable dry-docking to proceed |

CLASSIFICATION SOCIETIES

Almost every major ship comes under the invigilation of a Classification Society which is an independent organisation empowered in law to ensure high standards of design, seaworthiness, and compliance with steadily increasing statutory obligations. The major Classification Societies include:

- The American Bureau of Shipping based in New York
- Bureau Veritas of France
- Det Norske Veritas of Norway
- Germanischer Lloyd based in Hamburg
- Lloyd’s Register of Shipping from the UK
- Nippon Kaiji Kyokai of Japan

Amongst papers from the Classification Societies many will be found headed ‘British Corporation’. This was the most commercially aggressive of all Societies, founded in Glasgow by Scottish and Northern Ireland interests in 1890. Following excellent working relationships between British Corporation

and Lloyd's during the Second World War, the two Societies merged in the late 1940s making the reconstituted Lloyd's the largest Classification Society in the world. The papers of British Corporation are of great historic importance.

The endorsement of a plan by a Classification Society indicates their approval of the design. Such plans are often amended in ink and have a stamp with words like 'Lloyd's Approved'.

KEY TECHNICAL DOCUMENTS

In addition to the ship plans, all ships have papers which are essential during construction and operation. They include the:

- Building Contract – regarded as a private document and not for publication;
- Ship Specification – a working document interpreting the contract;
- Building Certificate – provided by the Builders on completion of the contract;
- Certificate of Compliance – supplied by the Classification Society;
- Certificate of Registration – supplied by the local Port Registration Officer and endorsed by the Registrar of Shipping and Seamen in Cardiff (if British).

The Specification of a modern ship can be a fairly large multi-page document, often in book form. From the historic angle, it may be important to keep catalogues of items aboard the ship, such as steering gear. Such catalogues are useful assets to any maritime library.

NAVAL ARCHITECTURE INSTRUMENTS

The design of ships requires many aids ranging from hard pointed pencils through to the most sophisticated instrument, the Integraph, a mechanical device used for calculating the area enclosed by a given curve, or the volume enclosed by a given surface. Recent developments with computers has changed this, but in historical terms, the ship design collection must include some representative tools from the following:

- Measuring Scales – these are highly accurate measuring 'rulers'
- Slide Rule
- Barrel Slide Rule
- Drawing Instruments
- Planimeter
- Integrator
- Integraph

SHIP PARTICULARS

The listing and cataloguing of large plan collections is a significant task. However the need for technical data on the ship itself must not be overlooked.

Computers can be used and appropriate spreadsheets designed for the purpose, but for speed and simplicity the use of printed Particulars Sheets is recommended. Again these can be tailored to meet the types of ship in the collection and can have special features inserted.

The author uses different sheets for:

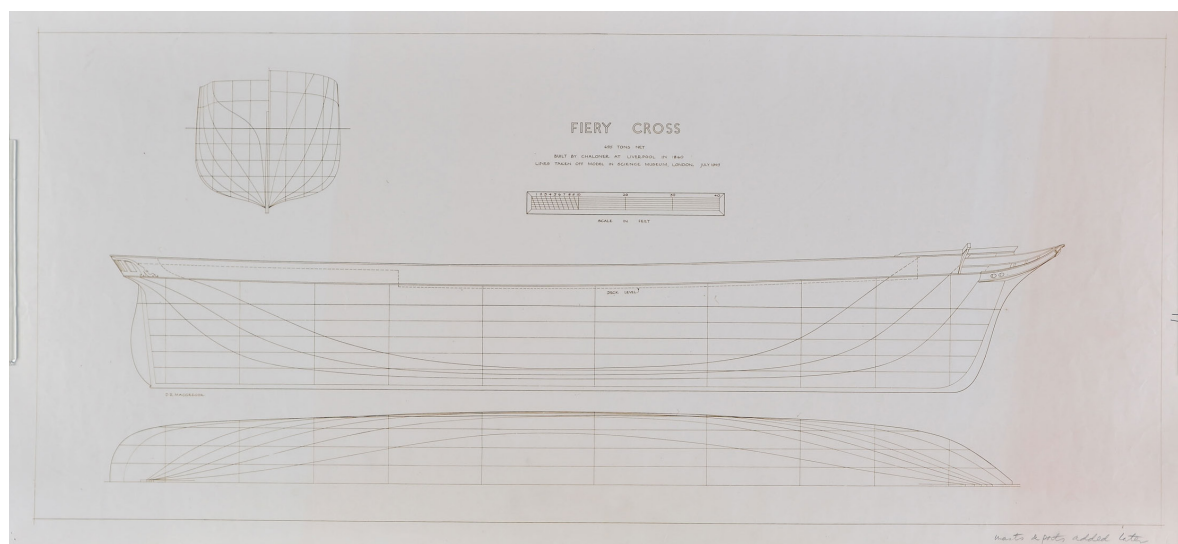
- Powered Merchant Ships
- Merchant Sailing Ships
- Powered Warships
- Sailing Warships
- Small Craft

CLOSURE

Donors of plans may request, for commercial secrecy, their papers be unavailable for a given period. This is reasonable provided the period does not exceed say four or five years, as most technical developments are public knowledge within 18 months of development.

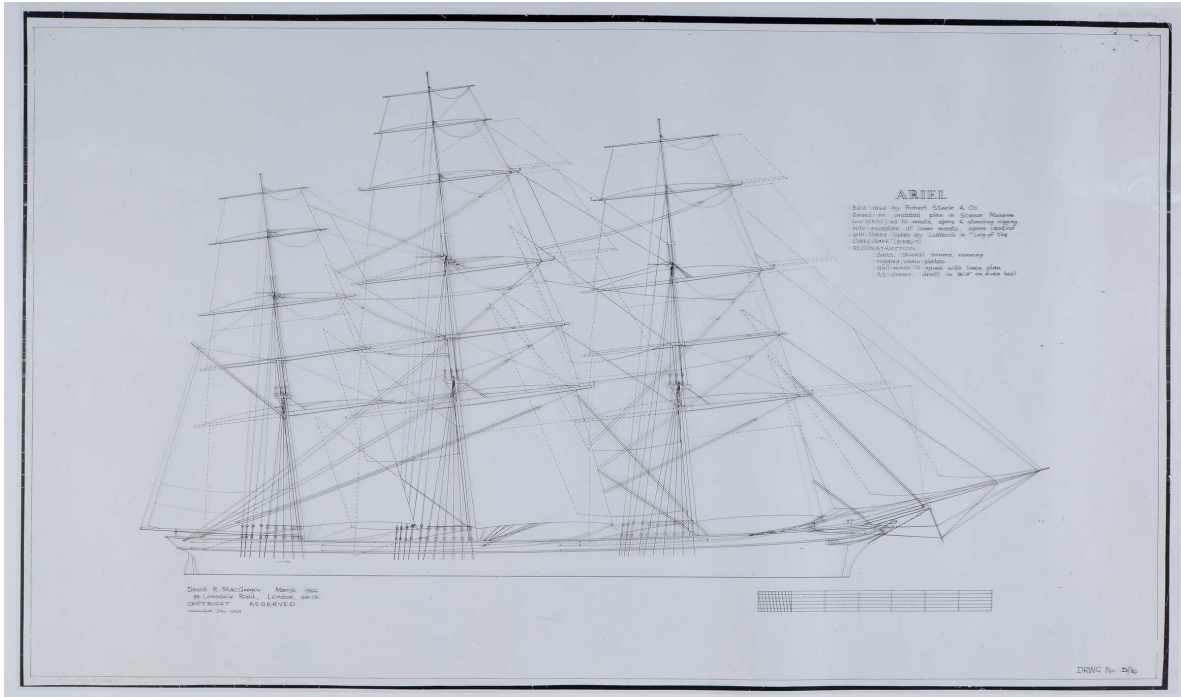
Some Important Collections of Ship Plans in the United Kingdom

- University of Glasgow Archives, The University, Glasgow G12 8QQ
- The National Maritime Museum, Greenwich, London SE10 9NF
- Strathclyde Regional Archives, Mitchell Library, North Street, Glasgow G3 7DN
- Tyne and Wear Archives, Blandford Square, Newcastle-upon-Tyne NE1 4JA
- Denny Ship Model Experiment Tank, Castle Street, Dumbarton G82 1QZ (This collection is mainly hydrodynamics material)



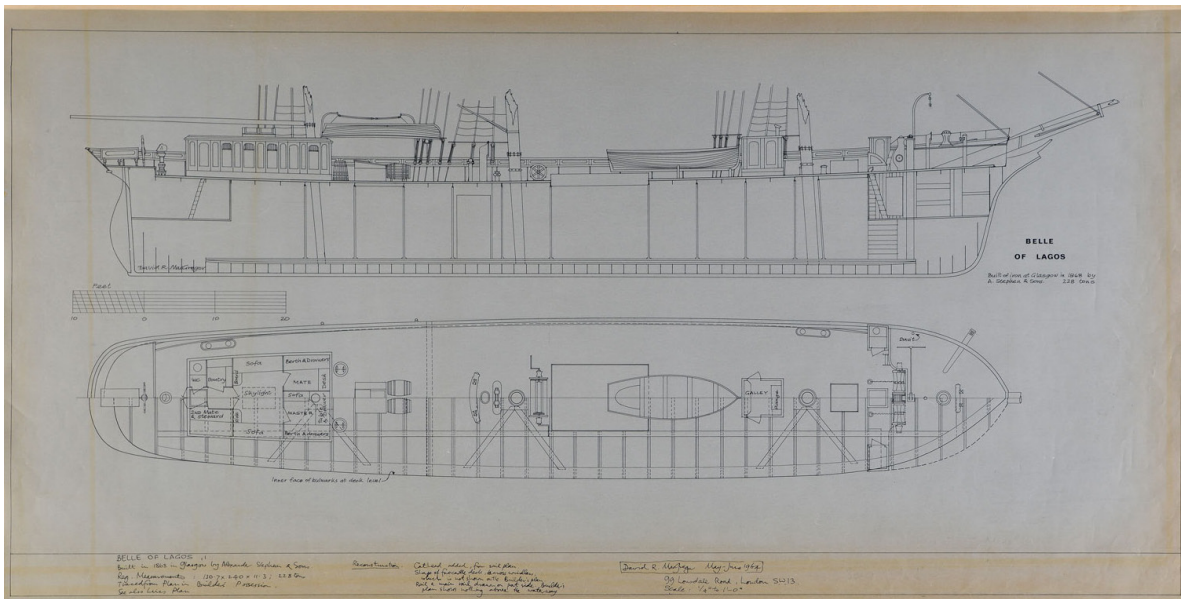
A lines plan of the 'Fiery Cross'

BRSGB 2012.00946 © SS Great Britain Trust, Bristol



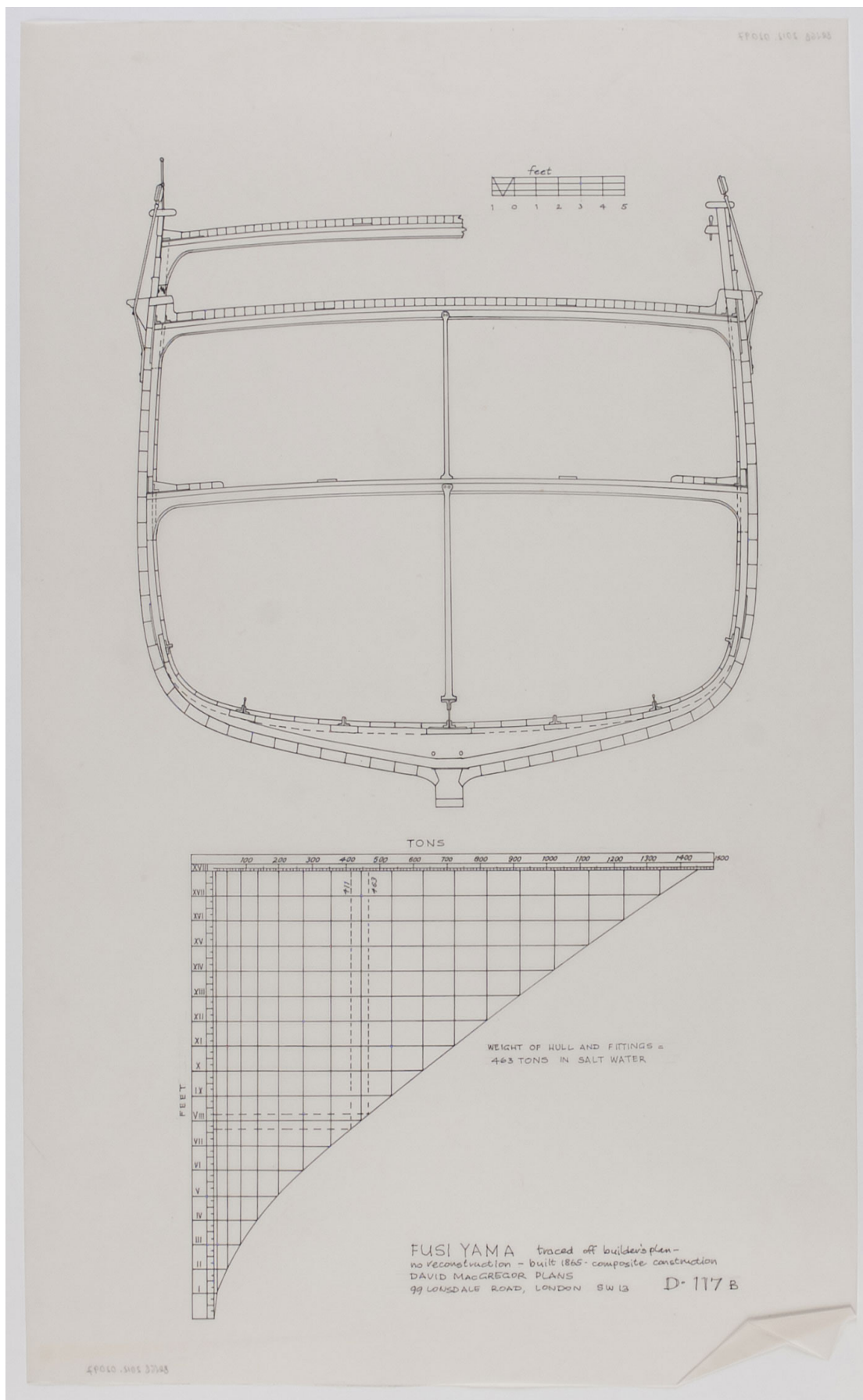
Rigging plan of the 'Ariel'

BRSGB 2011.1104 © SS Great Britain Trust, Bristol



General arrangement for the 'Belle of Lagos'

BRSGB 2011.1237 © SS Great Britain Trust, Bristol



Midship section of the 'Fusi Yama'

BRSGB 2012.02097 © SS Great Britain Trust, Bristol

BIBLIOGRAPHY

This is a small select bibliography giving books that are clear and straightforward, giving simple introductions to this complex subject.

Professional Transactions – among the most valuable of documents available to students and curators are the transactions of the following institutions:

- The Institution of Engineers and Shipbuilders in Scotland, Clydeport Building, Robertson Street, Glasgow G2 8DS

Commencing in 1857 and continuing to the present day, the 1600 published papers deal with every aspect of engineering, making this one of the most valuable reference tools available.

- The Royal Institution of Naval Architects, 10 Upper Belgrave Street, London SW1X 8BQ

Commencing in 1860, these continue until the present day, and encompass a higher proportion of papers with advanced theoretical input.

HISTORY OF NAVAL ARCHITECTURE AND SHIPBUILDING

- *Architectura Navalis Mercatoria* Fredrik Henrik af Chapman, Stockholm 1768. (Many reprints since including that of Adlard Coles, London 1971)
- *The Shipwright's Trade*, Sir Westcott Abell, Cambridge University Press 1948
- *The Institution of Naval Architects 1860 –1960*, K C Barnaby, The Royal Institution of Naval Architects, London 1960
- *Song of the Clyde – a History of Clyde Shipbuilding*, Fred M Walker, Rev edition John Donald / Birlinn Edinburgh 2001

20TH-CENTURY NAVAL ARCHITECTURE

The first three books are all in imperial units but are amongst the greatest teaching volumes ever produced in this country. The first is by a Director of Naval Construction and the other two by distinguished Glasgow Professors.

- **A Manual of Naval Architecture**, Sir W H White, John Murray, London 5th edition 1900
- **The Design and Construction of Ships**, Sir John Harvard Biles (2 vols) Charles Griffin, London 1923
- **Theory of Naval Architecture**, A M Robb, Charles Griffin, London 1952

In metric units, ship theory has been greatly assisted by two volumes, the first of which is inexpensive and fairly easily understood.

- **Naval Architecture**, Brian Baxter, Teach Yourself Books, Hodder and Stoughton, London 2nd edition 1976
- **Basic Ship Theory**, Rawson and Tupper, Longmans London 1968 and many other editions

NAVAL ARCHITECTURE AND DRAWING OFFICE INSTRUMENTS

- **Theory of Naval Architecture**, A M Robb (above), Chapters 1 and 2 give the best, although mathematically complex descriptions of measuring instruments.
- **History of Engineering Drawing**, P J Booker, Northgate Publishing, London 1963
- **Drawing Instruments**, Michael Scott-Scott, Shire Publications, Aylesbury 1986

SHIPBUILDING IN TIMBER

- **How Wooden Ships are Built**, H Cole Estep. Penton Publishing, Cleveland, Ohio 1918, W. W. Norton, New York 1983
- **Wooden Ship-Building**, Charles Desmond, Rudder Publishing, New York 1919
- **From Tree to Sea: The Building of a Wooden Steam Drifter**, Ted Frost, Terence Dalton, Lavenham 1985

SHIPBUILDING: IRON, COMPOSITE, AND STEEL

- **The Iron Ship – Brunel’s ss Great Britain**, Ewan Corlett, Chatham Publishing. 2nd edition. 1990. New reprint – ss Great Britain Project, Bristol 2011
- **From Slip to Sea: a Chronological Account of Shipyard Practice**, A C Hardy, James Brown, Glasgow 1926
- **Steel Shipbuilding**, Fred M Walker, Shire Publications, Aylesbury 1981

3 SHIP MODELS

BY BRIAN LAVERY, CURATOR EMERITUS, NATIONAL MARITIME MUSEUM

Ship models have long been one of the best ways of representing maritime history, and sometimes they have played a role in creating it. In 1667, when the Dutch raided the River Medway, Peter Pett of Chatham Dockyard rescued his ship models first, on the grounds that their capture would give away the secrets of his design. In 1696, Peter the Great took models back from his trip to England to found the new Russian Navy. In more recent times, Lord Mountbatten used one to persuade the government to finance the vastly expensive nuclear submarine programme.

The *Shorter Oxford English Dictionary* has no less than eleven definitions of model, but the one that applies here is 'a presentation in three dimensions of some projected or existing structure, or of some material object, showing the proportions and arrangements of its parts'. Besides ship models proper, maritime museums and galleries might contain topographic models of maritime sites, such as shipyards, dockyards, ports, and lighthouses.

Early models were not truly to scale and were often made for religious reasons. The ancient Egyptians put models of boats in pyramids and in Medieval and later times, sailors often put models of their ships, known as votive models, in churches. These were not made from plans and their proportions are generally wrong. Though they are not models in the strictest sense of the term, they are valuable as display items and historic sources, because they are close to the ships they portray and have an interesting 'feel' to them, and because we know very little about ships before about 1650 from other sources.

The most important stage in the development of the true scale model came about the middle of the 17th century. From that time, major ships were invariably built from plans and these provided a ready made resource for the modeller. It was also the time when monarchs built great ships to glorify their power and decorated them with extensive figureheads and carvings. Much of this glory was reflected in models they commissioned of the ships. In the 17th and 18th centuries ships' plans were usually drawn to a scale of 1 to 48, or 4 feet to the inch, and it was only natural that models should follow this. Even then, some models were made to odd scales, perhaps to fit into a particular space. By the middle of the 19th century the actual ships were often much larger, so a scale of 1 to 96 was sometimes used, while 1 to 192 is occasionally found in the 20th century. Some shipbuilders tend to 'metricate' their scales nowadays, perhaps using 1 to 100 or 1 to 200.

Though accuracy is important in selecting models for museums, very few are completely and literally accurate. Most model makers use some kind of technique, which is in a sense unrealistic. Navy Board models, for example, have the framing of the lower part of the hull left unplanked. Most types of model show the full hull of the ship out of the water, but with all the rigging and fittings in place - a situation in which a real ship would never find herself. Some types of model make compromises between cost, appearance and accuracy of detail. Builders' models have mass-produced fittings such as cargo winches and anchor gear, which are finished in types of metal which would not be used on real ships, while details such as doors, windows and deck planking are often drawn on rather than being manufactured. Some 20th-century modellers, however, show models on an imitation sea, and even include rust streaks on the hull for complete realism. Norman Ough, who died in 1963, was one of the leading exponents of this type of modelling.



The destroyer HMS Warwick of 1918 by Norman Ough
SLR1446 © National Maritime Museum, Greenwich, London, Royal United Service Institution Collection

Even if a model was made alongside the actual ship, a certain amount of caution is needed in using it as a historical source. Many were made to show the ship in her best light. Often they were commissioned at an early stage of the construction of the ship, but many details might be changed before she was launched or during her career at sea, so it is quite possible that a model does not show the ship as she actually was at any given moment.

Models are among the most common exhibits in maritime museums. Visitors of all ages can understand them and nearly always expect to see them there. Unlike a building, a ship has a limited life span and it is impossible to preserve real ships in large numbers, so models are the best way of representing them in three dimensions: indeed it might be argued that a model which was made alongside the ship, such as a Navy Board or builders model, is the best way of representing and commemorating the ship, in the way that a tombstone commemorates a person. Plans can give more detailed and accurate information, but are not usually visually attractive and cannot always be interpreted by a lay audience.

So far models have tended to be displayed in two different ways: either among other objects as part of a thematic display or in a gallery consisting entirely of models, to tell the story of ship models or of shipbuilding. Models are ideal for the last purpose, but the main problem is that they are not always to the same scale, which can be difficult to convey to the public.

Another possibility, which so far has not been exploited by museums, would be to take an individual model and explain it in great detail, using fibre optic lighting and supplementary video displays to highlight certain features. This would help get over one of the main problems with ship models – that they are often seen as too technical to appeal to a general audience.



The figurehead was used to identify this model as the St Michael of 1669 – the earliest English model of a known ship.

SLR0002 © National Maritime Museum, Greenwich, London, Caird Collection

Seventeenth-century models are almost the only source we have for the appearance and details of ships of the period, apart from paintings. From the 18th century onwards, when ships plans become more common, models are less essential as sources, though they give much detail of the fittings of ships. Much work remains to be done in the study and history of models, which have been almost completely neglected as a cultural resource. Apart from study in the archives much could be learned by fibre optic examination of the insides of models and by the use of x-rays, while catalogues covering a particular type, such as the Navy Board model, in different museums and private collections throughout the world, would give a broader perspective.

TYPES OF MODEL

NAVY BOARD

Also known as the ‘Admiralty’ and ‘Dockyard’ model, the Navy Board model evolved in England in the middle of the 17th century. It was named after the Navy Board, which controlled shipbuilding for the Royal Navy and, it is claimed, commissioned most of the models, though this is doubtful.



A 50–54-gun ship of c 1664, perhaps a prototype for several ships built at that time, which turned out to be larger.

SLR0217 © National Maritime Museum, Greenwich, London

Very early examples, such as one of a 50 to 54-gun ship in the National Maritime Museum, Greenwich, are almost completely unplanked but show most of the decoration of the ship. By about 1670, a typical model showed the ship planked above the lower wales, the extra thick planking at the widest point of the hull, but this type of model always retained the unplanked frames below that. The frames themselves are one of the most important features of a Navy Board model. Sometimes frames were omitted to show the interior of the hull, and the style of framing was not like that of a real ship. They give very good detail of the layout of the ship, including the positions of the guns, capstans, masts, ladders etc.



*The classic style of Navy Board model, with open frames and planking above the wales. Warship, Fourth-rate, 50 guns c 1725
SLRo431 © National Maritime Museum, Greenwich, London*

Navy Board models are extremely rare and usually fetch several hundred thousand pounds at auction. They are mostly made to a scale of 1:48, which was the standard for ships' plans of the period. It was formerly believed that they were used for the approval of ship designs but this is unlikely, because such a model usually took several years to make. It is more likely that they were made for commemorative or decorative purposes.

GEORGIAN MODELS



One of the best Georgian models is that of the Bellona, now known to have been made by Thomas Burkett, William Thompson of Chatham Dockyard in 1759–60. It is shown on its launching ways. Later the model was coppered and may have been taken to King George III to demonstrate the principle of coppering.

SLRo338 © National Maritime Museum, Greenwich, London

The Georgian model was a development of the Navy Board model and is often confused with it. A solid hull replaced the open framing. The lower hull was either planked or painted. The type began to develop at the beginning of the Georgian period in the 18th century and the standard of craftsmanship was as high, or higher, than that of Navy Board models, with more finely carved decorations. After about 1750 some were mounted on model launching ways on which the ship can slide down. Some of the best are believed to have been made by George Stockwell, who worked as a shipwright in Sheerness Dockyard from 1744 to 1804. A commercial model maker of this time was Allen Hunt of Southwark, London, who made models for the Duke of Northumberland amongst others and also cleaned and restored models. Like Navy Board models, the most common scale was 1:48, though odd scales were often used for very large or very small ships, to make them more suitable for display.

RIGGED MODELS

Almost any kind of sailing ship model can be rigged, but Navy Board and Georgian models were rarely fitted with masts, yards and rigging in their original state, apart from a period near the beginning of the 18th century when they may have been used to develop improved methods for rigging ships. In most cases where it is present in such models, the rigging was fitted later.



Rigged models were rare in the early 18th century, though some were fitted with masts and yards at a later date. However this one, of a 50-gun ship c 1710, is believed to have its original rigging largely intact.

SLRo396 © National Maritime Museum, Greenwich, London. Accepted by HM Government in lieu of Inheritance Tax and allocated to the National Maritime Museum, Greenwich, London, 1993

By the second half of the 19th century, it was more common to rig models than not. Sailor-made and prisoner of war models are almost invariably rigged, for the sailors who made them were far more familiar with the rigging than with the shape of the hull.

BLOCK AND HALF-BLOCK MODELS



A block model of the Elizabeth, a 70-gun ship launched in 1737
SLR0451 © National Maritime Museum, Greenwich, London

A block model is one that is carved from solid wood rather than assembled in the way of a Navy Board model. Most were made by 'bread and butter' construction, in which several planks of appropriate thickness were cut to the shape of the horizontal sections of the hull, fixed together, then carved to the final shape. 'Bread and butter' construction is not always easy to identify on the final model, unless it has tended to crack through age, causing visible joins. This type began to evolve in Britain late in the 17th century, and these, rather than the Navy Board models, were probably the ones which were shown to the Lords of the Admiralty for the approval of new ship designs. Often they were painted with the details of the gunports and decoration of the ships. Block models continued to develop in to the 19th century, and they formed the basis of the builders' models, which are described later.

The half block model is simply a variation of the block model – for reasons of space or economy, only half the ship was shown and it was mounted on a board, usually with the ship's name painted on it. As such it was ideal for display on a wall, in a company boardroom for example. As a further sophistication, some models of the Victorian period had a surfaced silvered mirror fitted instead of the backboard so that it looked like a full hull model.

PRISONER OF WAR MODELS

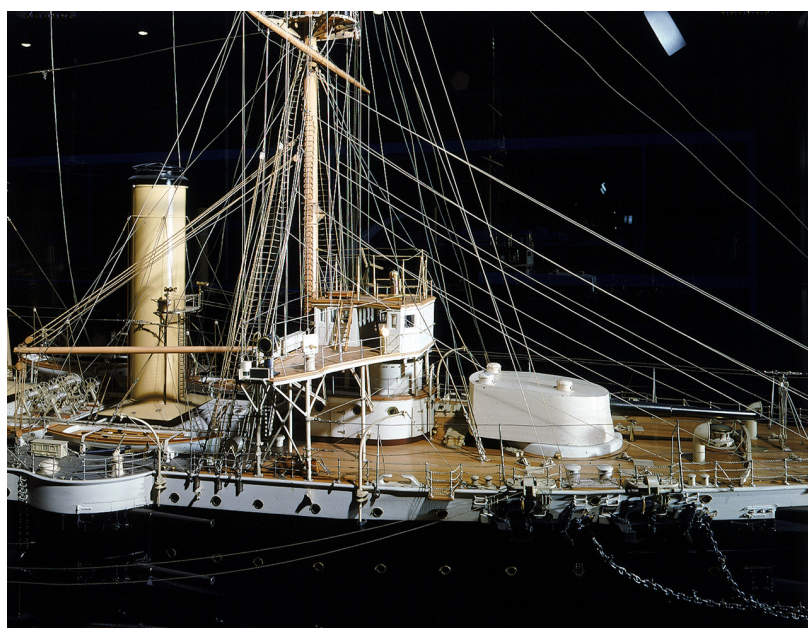
These models were developed as a means of supplementing their income by French prisoners of war in Britain, mainly during the Napoleonic Years, though there is evidence that some Americans made models during the war of 1812. The classic prisoner of war model was made in bone, though ivory and wooden models are also known. As the market for such models developed in England, the quality tended to improve and some were made after the end of the wars in 1815.



A model of a French two-decker in prisoner of war style, made in bone c 1800
SLR0618 © National Maritime Museum, Greenwich, London

Prisoner of war models are generally very fine in detail and are almost always rigged, but the maker was a seaman rather than a shipbuilder and he obviously had no access to the plans of the ship. The proportions are often wrong, with hulls that are too narrow, bowsprits, which are too long and steep, and masts that are too high. Often the name in the stern has little relationship with any actual ship of that name, and was probably added to enhance the value. Some have special features, such as guns that come out when a cord is pulled. In displaying them the curator has to be aware of their inaccuracies. In a sense they are more useful as an insight into the life of prisoners of war than as an accurate representation of a ship. The market for prisoner of war models is more developed than any other, because of course they were made for the market place in the first instance. They can still command high prices.

BUILDERS' MODELS



A very detailed builders' model of the cruiser Leviathan of 1901
SLR1326 © National Maritime Museum, Greenwich, London



Models were also made of humbler ships, such as the tramp steamer Kenwood of 1910
SLR1390 © National Maritime Museum, Greenwich, London

In the second half of the 19th century, the new shipyards of Scotland and northern England began to produce models of the ships they had built, mainly for advertising purposes. Such models were put on the company stand at the great international exhibitions, while at normal times they were to be found in the company's boardroom and offices. In addition, the shipowners often specified in the contracts for new ships, that a model of a high standard, in a fitted glass case, should be given to them. These also found their way to exhibitions, or into travel agents' windows.

Builders' models are very striking in appearance, though they were made to a tight budget. The hull was of 'bread and butter' construction, hollowed out to reduce weight during transport. The hull was painted in the colours of the shipping line. Some details such as doors, windows, hatches and deck planking were drawn on to the hull and decks, to save time. Metal fittings were often mass produced by specialist companies and plated or gilded in silver, gold or copper to enhance the appearance and prevent tarnishing. Large numbers of builders' models were made, and many still come on the market. They were usually to a scale of 1:48 until the 1950s, when much larger ships demanded smaller scales such as 1:96 or 1:100.

Since the 1950s the Royal Navy has commissioned models of every class of warship for display in recruiting offices. These models are very attractive and accurate and continue the tradition of the builders' model.

PRACTICAL MODELS

Since the 17th century, shipwrights and amateur scientists had suggested using ship models to test their theories, or the performance of projected ships, but this had little real effect until the 1870s when William Froude built the first modern test tank at Torquay, Devon, in which models were towed through the water. He developed a method of making models from wax on a wooden frame, and cutting the shape of the hull very accurately from the plans. Test tank models were originally made without any fittings or detail, though a few were later converted into builders' models. Otherwise, they are usually painted yellow and sometimes have lines marked on them to help with calibration and measurement during the tests. Test tank models are rarely sold in the auction market, but can be seen at the Denny Test Tank, part of the Scottish Maritime Museum, in Dumbarton.



A modelmaker uses a machine to cut out the lines from the plan of a ship in the Vickers test tank. Later it will be filed down to remove the 'steps' and give a very accurate reproduction of the intended shape.

We regret that enquiries have not been able to identify the copyright holder and would welcome any information that would help us update our records

For the construction rather than the design of ships, models could occasionally be used to plan the arrangements of the frames, which formed the skeleton, or the planks, which covered wooden ships.

Rather more common are plating models for iron and steel vessels, used for arranging the layout of the plates in relation to frames, and for calculating the dimensions of the plates in a complex three-dimensional setting.



A plating model of the Bardic Ferry of 1957, the first purpose built roll-on roll-off or 'ro-ro' ferry.

SLR1687 © National Maritime Museum, Greenwich, London

PARTIAL MODELS

Models of parts of ships usually represent the bows, stern or midships section in the centre of the ship. They can show some of the internal details, such as decks, guns and cabins. A longitudinal model shows one half of the ship, but unlike a half block it is intended to show the interior rather than the outside.



This model of a 74-gun ship, the Intrepid, was made to show to King George III c 1770, and the names of the individual timbers are marked on it.

SLR0525 © National Maritime Museum, Greenwich, London

Structural models show the framing of the ship, with the planks left off. They are quite common for wooden sailing ships, rarer for iron and steel ships. Models can also be made specially to show the accommodation, particularly on passenger ships. These range from a gigantic model of an ocean liner with one side cut away to show the interior, to a model of a single cabin. Many models were made of ships' fittings, such as anchors, capstans, rudders, propellers, steering wheels and guns, often to demonstrate new ideas with a view to getting a patent.

AMATEUR MODELS



A sailor-made model of a brig, c 1880

AAA0068 National Maritime Museum, Greenwich, London. We regret that Museum enquiries have not been able to identify the copyright holder and would welcome any information that would help us update our records. Please contact the Picture Library.

The earliest 'amateur' models were made by those involved in the shipping industry, such as seamen of the Victorian era who made crude but often charming models of their own ships. At the end of the 19th century, the sailing of model yachts on ponds became a very popular hobby, and such models tell us as much about the social history of the period as about ships, for they are not always accurate as models. Static models on the other hand, whether made from kits or 'scratch built' from materials and plans acquired by the modelmaker himself, can be very accurate, but the quality of amateur models, as one might expect, can vary enormously. At their best they are very attractive, though they are only a secondary source in historical terms i.e. one modeller's interpretation of the ship. In recent years, very accurate working models have been made for pond use, often fitted with radio control.

EXHIBITION MODELS

As used here, the term 'Exhibition model' is defined as one specially commissioned for museum display. They have advantages in that they can cover subjects and periods for which original models are not available, that they can be made to a common scale, and that they can be used to highlight and explain certain features to the public. When commissioning an exhibition model, a curator is usually constrained by a budget, and must think very carefully about what is to be achieved. Quite simple models can tell a story when they are assembled together to show, for example, the increase in size of ships over the years. Models of ports and shipyards, on the other hand, can be very expensive if full details are to be used.

Obviously good research can do much to enhance an exhibition model. Plans of ships are available from several sources. For older vessels, archaeological reports are often the most valuable sources. In either case, good photographs of the original can be used to augment the plans.

TOPOGRAPHICAL MODELS

Sometimes known as dioramas, topographical models can represent shipyards, dockyards, ports, and navigational features such as lighthouses. Most are to a very small scale, because they cover a wide area.



The topographic model of Sheerness Dockyard, c 1774, shows buildings, fortifications and ships under construction and repair in great detail.

SLR2148 © National Maritime Museum, Greenwich, London

Among the earliest ones were six models of the Royal Dockyards made for the Admiralty in 1772 to 1774. In more recent times, port authorities often commission models to stand in their boardroom or reception area. They often show a whole range of building and structures such as offices, dry docks, building slips, cranes, and workshops, as well as models of the ships and small craft (usually in waterline) which might use the facility.

MODELMAKERS

It is rarely possible to identify an individual who made a model, except in fairly recent times, for modelmakers have tended to be self-effacing craftsmen. Builders' models were usually made in the shipyards themselves, or by companies, which specialised in such work, such as Mackenzie and Co of Glasgow and Bassett Lowke of Northampton. Often a plaque can be found in the case, giving the name of the company that made it. Sometimes information is actually concealed on the inside of the model.

Pure forgeries are rare among ship models, except for half-blocks and prisoner-of-war models; the cost of making a Navy Board model, for example, would not be much less than the price it would fetch at market. A buyer, however, must beware of over-restoration, which might make a model into something it was not intended to be. There are cases, for example, where parts of several original models have been put together to make a whole.



A very early glass case for ship models, in the collection of the US Naval College, Annapolis, Maryland. No examples of this style are known in the UK.

© Brian Lavery

Display cases were often made with the models. The earliest are recorded by Samuel Pepys in the 17th century, though the case probably had to be opened to view the model. By the late 19th century, glass technology had developed sufficiently to allow the making of the true glass case and very elaborate ones were made for builders' models, for example. When putting models on display in museums, it is quite normal to put several items in a larger case and there is a temptation to get rid of the original case. This should be strongly resisted, as the case might belong with the model and is often a fine piece of workmanship in its own right.

COLLECTIONS OF MODELS



Visitors are shown round the Model Room attached to the Admiralty Offices in Somerset House, London, in 1842. Many of the models later went to the National Maritime Museum, and some can be identified in this picture.

PAD1391 © National Maritime Museum, Greenwich, London

The largest collections of models can be seen in the national museums – the National Maritime Museum at Greenwich, the Science Museum in South Kensington and the Merseyside Maritime Museum in Liverpool. The Greenwich collection, which originated with the Model Room at the Admiralty in the 1820s, is particularly strong on Navy Board and Georgian models, though it attempts to include ships of all types and periods. The Science Museum also has a broad collection, with a notable group of British coastal craft and fishing boats. The Merseyside Maritime Museum has nearly 800 models, mainly of British merchant ships, often with a Merseyside connection, though it includes models of all types. The Imperial War Museum has models of 20th century warships, merchant ships, and related material.



A model of a 74-gun ship in the Merseyside Maritime Museum collections

© Brian Lavery, with kind permission of National Museums Liverpool

Many local and regional museums in shipbuilding areas have fine collections of the products of local shipyards – the Clyde Room in the Glasgow Museum of Transport and the shipbuilding gallery in Newcastle Discovery, for example. Small museums in coastal and fishing towns tend to have general displays, which use models to show local types of craft. More thematic museums, such as the Royal Naval Museum in Portsmouth, the Submarine Museum in Gosport, the Fleet Air Arm Museum in Yeovilton and the Scottish Fisheries Museum in Anstruther, have collections relating to their own special subjects.



No 1 Smithery at The Historic Dockyard, Chatham, was opened in 2010 as a partnership between National Maritime Museum, Imperial War Museums and Chatham Historic Dockyard Trust. The building provides storage for the two national collections of ship models as well as galleries.

© Chatham Historic Dockyard Trust

CONSERVATION

Ship models pose two special problems to the conservator. Firstly they are often very delicate, especially Navy Board models and rigged models. They have to be handled and stored with great care, and the hull has to be fully supported and protected during transport. It is difficult to underestimate the caution required when handling or moving a ship model. Secondly, many models are made from a mixture of materials – wood, iron, brass, silk thread for rigging, cloth for sails and so on. Lead, used on many amateur models of the late 19th century, is one of the most difficult materials because it tends to corrode in certain conditions. Often a distinctive white powder can appear on lead fittings as the metal degrades irreversibly into lead carbonate. This may indicate the presence of organic acids around the model.

Many older models arrive in museums in a damaged state, or deteriorate because of years in unsuitable stores. In such circumstances, the conservator has to consider how far he can go with restoration. In the early 20th century, some models were very heavily restored, making them attractive display items but destroying their validity as historic sources. If it is necessary to replace parts of the structure of a model (and this should only be done if it is absolutely necessary to consolidate the structure) then it is possible to use a different colour of wood, for example, to show exactly what is original and what is not.

When storing ship models, it is desirable to keep them in their original cases. Not only does this preserve the cases but it also makes them much more accessible for researchers when they are not on public display. Whether in storage or on display, light and humidity levels have to be carefully monitored, as a sudden change in humidity or regular fluctuations from heating systems can cause great damage.

BIBLIOGRAPHY

John Franklin, *Navy Board Ship Models*, 1987

Ewart Freeston, *Prisoner of War Models*, 1973

Robert Gardiner, *The Sailing Frigate, a History in Ship Models*, Barnsley, 2012

G S Laird Clowes, *Sailing Ships: Their History and Development*, Science Museum, 1936

Brian Lavery and Simon Stephens, *Ship Models, Their Purpose and Development from 1650 to the Present*, London, 1995

National Maritime Museum, *Catalogue of Ship models, Part I; Ships of the Western Tradition to 1815*, 1980

E W Paget Tomlinson, *A List of the Museum's Collection of Ship Models*, City of Liverpool Museums, 1967

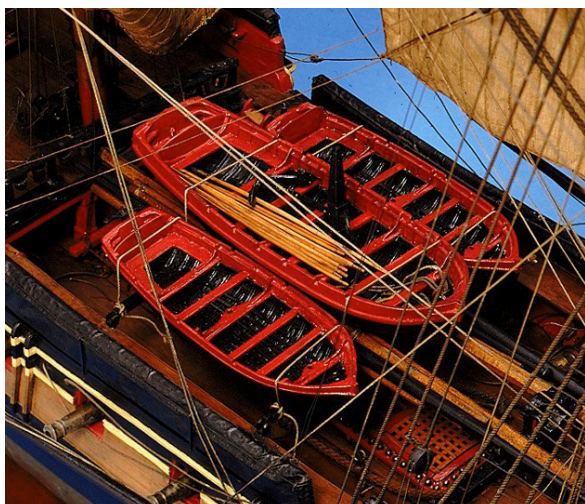
4 MUSEUM BOATS AND HISTORIC SHIPS

BY MATTHEW TANNER, CHIEF EXECUTIVE AND FORMER CURATOR, SS GREAT BRITAIN TRUST

INTRODUCTION

The successful approach to the care and management of historic ships and boats is systematic, and applies equally to ships or boats. There is no difference in the principles that can be followed – in that sense boats and ships are indistinguishable. ‘What is the difference between a ship and a boat?’ is a common question for which there is no definitive answer. Perhaps ships can carry boats while boats cannot carry ships? Historically, it could generally be said that ships had decks while boats were open. This is confused by modern sailing yachts and cabin cruisers, which might be quite small but have decks to provide accommodation. A fishing vessel is invariably a boat, however large. Submarines started off very small around 1900, and are still referred to as boats, even if they are major warships carrying enough nuclear weapons to destroy several major cities. Shipyard workers, for example on Clydeside, often referred the vessel they were working on as a ‘boat’, and since they were in the business their vocabulary must be regarded as authentic. No doubt there are other exceptions, but in general it is safe to say that a large vessel is a ship and a small one is a boat. Some might say the distinction is pedantic, but if a curator is to get the respect of the local maritime community and enthusiasts, it is important to get it right.

Size is also important, for the smallness of a boat as a museum object allows storage and display under cover and is also virtually the only way to ensure successful high-quality long-term preservation and interpretation.



Ship's boats on a model of a frigate, c 1805. They were used for many different purposes, including carrying stores, laying out anchors, etc.

SLR0346 © National Maritime Museum, Greenwich, London



Modern ships' boats are usually lifeboats, though in the case of a cruise ship they can also be used to take passengers on trips, when they are known as tenders.

© Brian Lavery

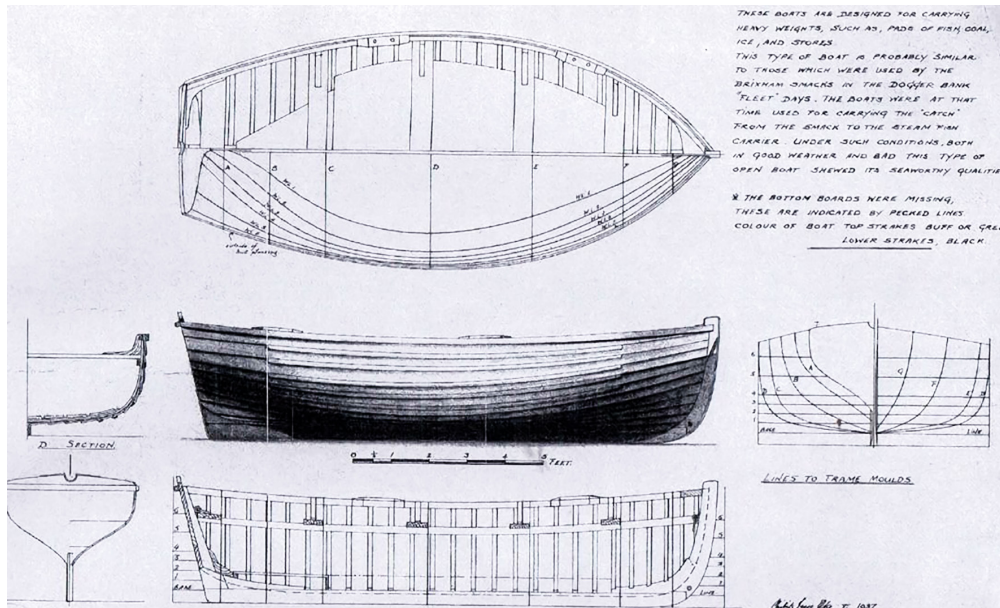
Conversely, it is often the very size of historic ships that provides difficult and very expensive challenges to the aspiring ship conservation project. They frequently cannot be brought under cover, and the long term maintenance let alone preservation of a ship that is neither under cover in a dry dock nor in constant operational use is particularly difficult. Such projects should be entered upon with extreme caution.

Despite their size, boats are as essential as larger ships for the human exploitation of rivers and seas which cover the globe, and, since they are so often very closely associated with a particular place, they may also be as significant for any small local museum as to the larger regional or national maritime museums.

One boat or ship can often appear much like another, despite the fact that they come in a huge variety of shapes, and have a large range of different functions. However, the interaction between shape and function is often one of the most interesting and essential features of an historic boat – it is not just a question of a platform that floats. It should be the curator or manager's aim to take time to understand the vessel and her context thoroughly.

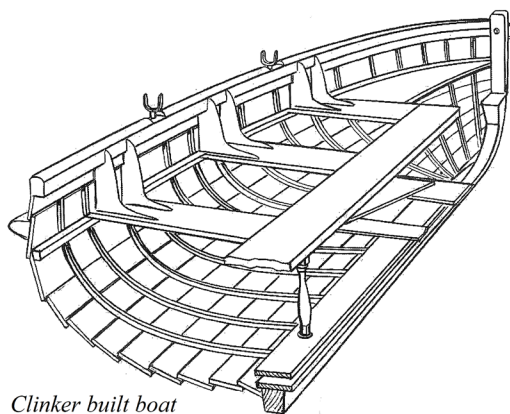


*A print of Wick harbour in 1875, showing how crowded it could become during the herring fishing season, by S. Read.
PAH5819 © National Maritime Museum, Greenwich, London*



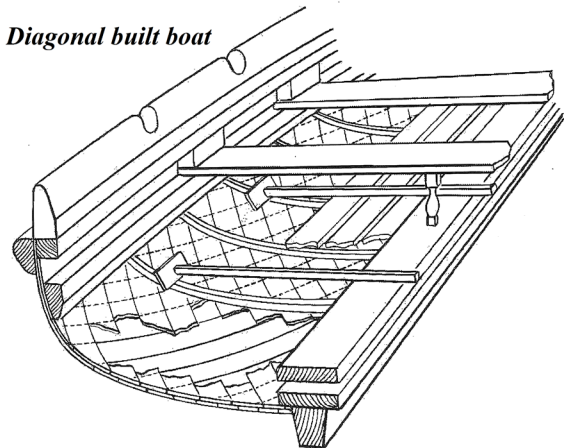
A Brixham trawler's boat

On loan to the National Maritime Museum, Greenwich, London



Clinker built boat

Diagonal built boat



Some boat construction techniques

Both images above from Admiralty Manual of Seamanship, 1909

CONTEXT AND ENVIRONMENT

The importance of recording the provenance and context is of course a commonplace for all museum objects, but it must still be reiterated. Boats, just as much if not more than other objects, must have their full context and environment recorded. Without it they become almost impossible to display effectively other than as some sort of gallery decoration, and are virtually worthless for future research. Almost every boat collection contains vessels that have been eagerly brought into a museum as objects, but arrive lacking much record beyond a basic inventory level. Boats may be acquired once they have been abandoned or sold by their original users. They may be in poor condition, and almost certainly will not come with any useful documents. It is the curator's duty to seek out every last drop of possible information in order to increase the value and significance of the boat, and ultimately to be able to address the question: "Why is the boat as she is in order to do the work she does."

The following questions may help in teasing out the necessary information:

The use and user

- What is the boat for?
- Who owned her? Who used her? How many crew were needed?
- How was she propelled? What rig was set?
- How was she used? What techniques were employed?
- When was she used? What time of year?
- What was she called? What was her local type-name?

The origin and builder

- Who built her? Where and when was she built?
- How common were these boats?
- How many did the builder create?
- What else did the builder create?
- How was the boat maintained?
- How has the boat been altered?

The environment

- Where was she used?
- What kind of environment was she used in? (e.g. small/large lake, fast/slow river, fast/slow tidal estuary, sheltered/exposed coastal water?)
- What were the prevailing wind patterns in which she was used?
- What shelter or harbour did she use?
- How was she launched?
- When was she used? When was she not used?

It is often difficult to answer every question. Comparison with similar vessels, and traditions from similar locations, can be very informative, but information implied in this way should be kept strictly separate from that which is directly related to the specific vessel in question.

TYPE-NAMES

An enjoyable element of looking at vernacular boats is the wonderful array of interesting and unusual type-names, such as Zulu, Mumble-Bee, Tosher, Jigger-boat, Wherry, or Trow; but they can provide a big pitfall for the unwary. Type-names are frequently used as identifiers of boats, but it is not always clear what they are identifying. They are frequently inconsistent through being used and adapted or preserved in many places over many years. Sometimes they are related to the function of the vessel, frequently appended with a particular place-name; sometimes they describe the rig of the boat, and sometimes they are more general names which have become attached to a particular boat type from a particular place at a particular time. They should not be treated as elements in a coherent classification system. Some words are particularly misleading. The term 'yawl', for example, is often used in a modern sense to describe a two-masted yacht rig, but in fact it derives from the same North European root meaning simply 'small boat', as does the similar common term 'yole'. Thus many boats described as either yawls or yoles do not exhibit any connection with the two-masted rig at all.

While the type-name is an essential part of a boat record, it does not in itself define the boat. Add to this the fact that each new owner and each builder may well have introduced slight modifications to a new boat to seek some type of improvements so that very rarely would one boat be identical to another. Only in the field of dinghy and yacht racing has there been a particular drive to compete using classes of boats

that are identical or 'one-design'. On the other hand, many wooden racing boats in the 20th century have conformed to 'restricted class' rules which have allowed controlled development of shape and rig in order to seek improved performance. Some classes have thus undergone such transformation to the point where the latest boats are barely recognisable as belonging to the original class.



A model of the Scaffie Mary Ann of 1848

SLRo834 National Maritime Museum, Greenwich, London. We regret that Museum enquiries have not been able to identify the copyright holder and would welcome any information that would help us update our records. Please contact the Picture Library.

SHAPE: HIGH-LEVEL AND MEDIUM-LEVEL DOCUMENTATION

Given these caveats about the use of type-names, a full description of a boat must be based upon a detailed recording of her actual shape. The complex curves can be recorded in great detail, frequently through taking off the 'lines of the boat', this process involves detailed measurements of the boat shape by recording the curve of the timbers in three dimensions. Once taken, these measurements can be drawn up on paper or on a computer in order to recreate and thus preserve the actual shape of the boat. These line drawings, while extremely useful and effective, can be time-consuming and require practice to reach a useful level of competence. Fortunately, mechanical and digital systems are currently being developed and tested to allow accurate high-level recording of boat shape without the problems inherent in the manual system. Recording boat shapes with digital cameras and other systems will and should become more important and more common as resources for the acquisition of boats dwindle.

As an alternative, it is possible at least to categorise the shape of a boat at a medium level without investing in manual lines recording. The key features of boat shape can be recognised by asking simple questions such as: Does the boat have two ends or one? Does it have a keel? Is it flat-bottomed? Such questions can be organised into a coherent classification system. The perhaps most reliable and respected system is described in detail and excellently illustrated by McKee in Chapter 6 of his *Working Boats of Britain*. This book is essential reading. Recording boats in museum collections using the McKee system would create an invaluable research resource since it allows different boat shapes to be compared and classified simply and quickly.

CONSERVATION PLANNING OF HISTORIC VESSELS

Once a vessel has been identified, her conservation needs should be assessed. This is particularly important for significant historic ships. To achieve what is often a mammoth task requires dedication, planning, and a thorough analysis of the cultural significance of the ship and all the fabric within her. This is the task of a Conservation Plan, and is usually a requirement of most funding and grant aid bodies. Writing a good Conservation Plan is an exacting task, especially for a ship. Guidance can be sought from the Heritage Lottery Fund, but of particular use is *The Conservation Plan* by James Semple Kerr, and it is especially worthwhile to take a good look at existing complete plans, such as the Conservation Plan created for the *SS Great Britain*.

The one book that makes essential reading for all curators and owners of historic vessels must be *Conserving Historic Vessels* published by National Historic Ships UK, a unit based at the National Maritime Museum in London. It forms a thorough and comprehensive guide to the whole process of conserving a boat or ship, taking the reader step by step through the logical thinking processes from possible acquisition all the way to the operation or display of the vessel. In particular it draws a clear distinction between the two possible core outcomes of a conservation project: Fabric Preservation or Operation Afloat. Since these two concepts are mutually incompatible the book helps the boat owner in how to consider the options and make the careful and logical choices that must be made to retain integrity and authenticity in the project. This is a volume that should be on the bookshelf of every historic ship or boat owner before starting any project.

SUMMARY OF A CONSERVATION PLAN

Stage 1 – A detailed understanding of the vessel

1. Gather the evidence

- a – Documentary and archival records
- b – Physical evidence for the full history of the ship

2. Co-ordinate and analyse evidence

3. Assess and state significance (e.g. on a scale of ‘Exceptional, Considerable, Some or Little?’)

- a – What is its ‘ability to demonstrate’...(how early, seminal, intact, rare, or climactic?)
- b – What are its ‘associations’...(how important, intimate, intact, long, physical?)
- c – What are its ‘aesthetic values’...(what degree of unity in scale, form, materials, texture, colour)

Stage 2 – Guide future care and development of the vessel

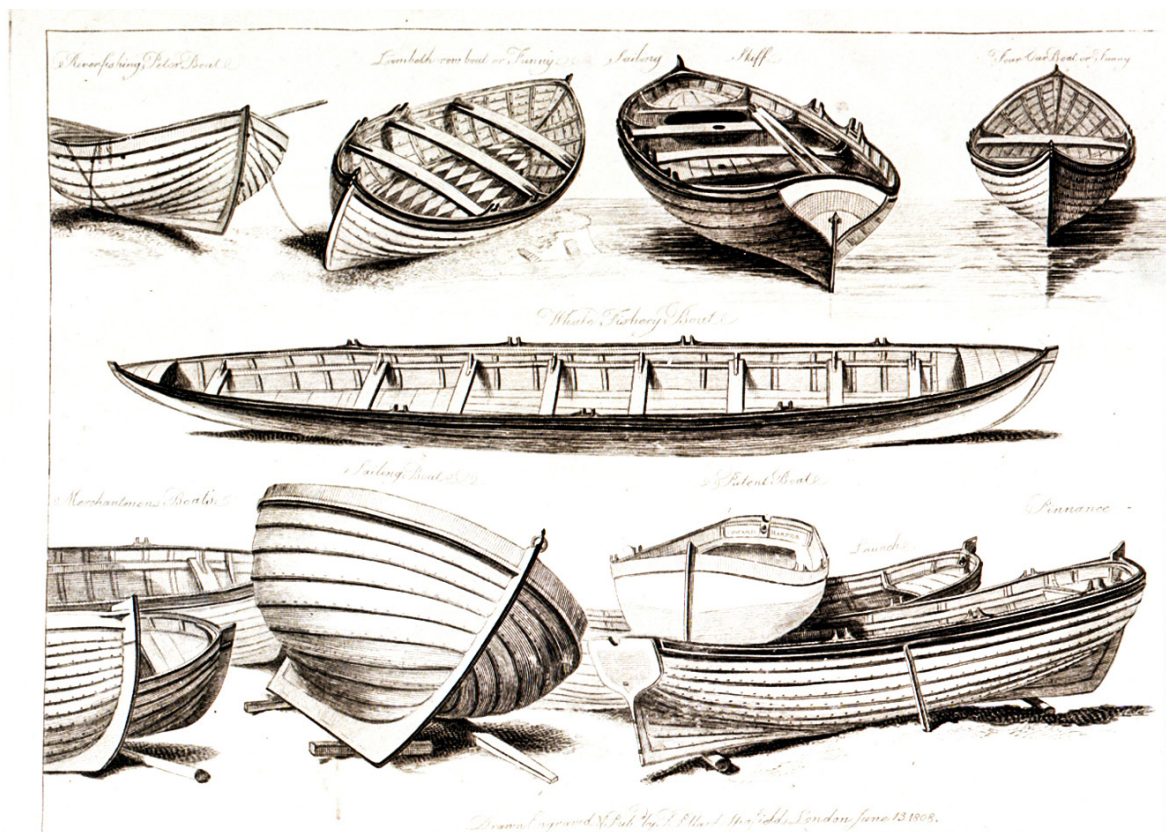
4. Gather information

- a – Requirements for retention of significance (as identified at Stage 1)
- b – Physical condition
- c – Requirements for feasible uses
- d – External requirements

5. Develop policy for retention of significance

6. Evolve strategies and options for implementation

(After Semple Kerr 1996)



River fishing Peterboat; Lambeth rowboat or Tommy; sailing skiff; four oar boat or Tommy; whale fishing boat; merchantmen's boats; sailing boat; patent boat; launch; pinnace.

Print, 1808, Artist & engraver Robert Pollard. PAD7747 © National Maritime Museum, Greenwich, London

SPECIAL ISSUES

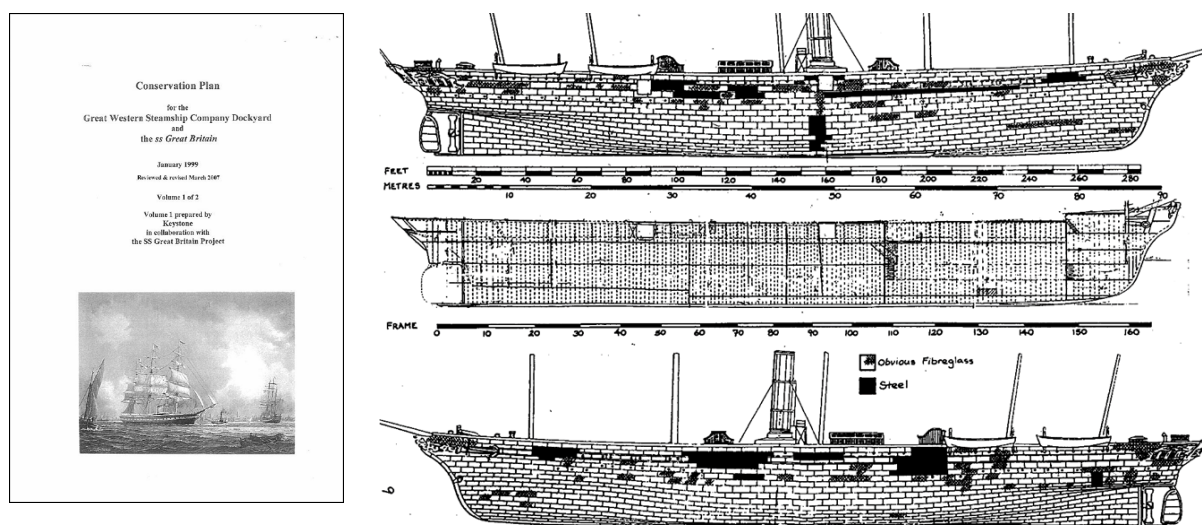
THE USE OF LANGUAGE

We often take it for granted that when we use a particular word we all mean the same thing by it. This has in fact rarely been the case for historic ships and boats, particularly for words such as 'conservation' and 'restoration'. In some places popular usage is for 'conservation' to mean the process of preserving a vessel, while 'restoration' is really the process of reconstruction. Frequently, 'restoration' is actually confused with 'preservation'. Such approaches can be simplistic and may serve to obscure the reality of work carried out on a vessel.

There are useful internationally agreed definitions for these and the related terms based on best practice in the wider heritage profession, and it is essential that these are understood, so that we all know exactly what we are all talking about without misunderstanding, particularly when it comes to writing Conservation Plans and work specifications. Here is a selection of key terms and their definitions:

Conservation

Conservation is the generic term for all the processes of looking after a ship or boat so as to retain the 'cultural significance' identified within them. Conservation includes the processes of Preservation, Restoration, Maintenance, Reconstruction, and Adaptation.



The cover of the SS Great Britain Conservation Plan, and a diagram mapping the state of the hull of the ship in 1998.

From ss Great Britain Conservation Plan <http://www.ssgreatbritain.org/brunel-institute/research-articles-papers>

Conservation Plan A Conservation Plan is the core management document that defines the vessel in terms of its surviving fabric from any period of its working life, analyses the fabric for its cultural significance, and develops a set of policies and plans for the most appropriate retention of that significance. A Conservation Plan is a requirement of most Heritage Lottery Fund applications, but is a vital tool for the care of any size of boat or ship.

Preservation Preservation is the process of maintaining a ship or boat in its existing state, and retarding deterioration.

Restoration Restoration is the process of returning existing fabric to a known earlier state by removing accretions or by reassembly of existing parts without introducing new material. It is very often confused with 'reconstruction'.

Reconstruction Reconstruction means returning the ship or boat as nearly as possible to a known earlier state, and is distinguished by the introduction of materials (new or old) into the fabric. This is not to be confused with either re-creation or conjectural reconstruction. Reconstruction is often and erroneously labelled as 'restoration' or even 'preservation'.

Adaptation Adaptation means modification to suit compatible uses proposed in a Conservation Plan

Compatible Use Compatible Use means a use that involves no change to the culturally significant fabric, or is substantially reversible, or requires minimal intervention

Cultural Significance Cultural Significance is the term given to elements of the physical fabric that have been identified, usually in a Conservation Plan, as having at least some significance within the cultural context on a national, regional or local scale.

Fabric Fabric means all the physical material of the ship or boat

Maintenance

Maintenance means the continuous protective care of the fabric, and is distinguished from Repair. Repair involves restoration or reconstruction and it should be treated accordingly.

Originality

Originality refers to fabric that can be identified as belonging to the working life of the vessel. This concept is often misunderstood through confusion with the idea that ‘original’ must mean the point of time at which the ship or boat was born, irrespective of whether that point has any significance. Sometimes the form and fabric of a vessel at her birth is clearly the only element of significance, at others there are clear accretions and changes that have occurred during the working life and that may have significance too. These must always be taken into consideration in a Conservation Plan, and frequently have greater significance than fabric dating back to the launch. For example, the fabric of *HMS Victory* that relates directly to the Battle of Trafalgar is often given more significance than the fabric that dates from her launch 40 years earlier. A further warning should be given against assuming that the ‘working life’ somehow continues when the vessel is brought into conservation or a museum. There is a clearly identifiable cut-off point to the working life on entry into a museum that allows all fabric from before that point, but not after, to be considered original to the object.



HMS Victory in 2012, showing the major restoration/reconstruction of timbers in the bow.

© Brian Lavery

PRESERVATION VS. RESTORATION OR RECONSTRUCTION

The preservation of historic ships and boats has often been a thorny issue. It is as viable to preserve a wooden boat as it is to conserve any other museum object such as paintings or furniture. The skills required, however, are not at all the same as those of a boat-builder or repairer. If a boat is deemed sufficiently important and significant, then it really should receive the attentions of a professional ship or boat conservator. These skills are rare – combining trained conservation skills with traditional boat and ship-building craftsmanship – but highly recommended. Such conservation advice and help is available from a few of the major maritime museums. The best ship or boat conservators have a thorough grounding in ship/boat-building and are also qualified in conservation.

Often, the idea of interpreting a boat by floating or even operating them is one that is deemed appealing to visitors. However, notwithstanding the safety issues it must be remembered that to do this the boat usually needs to undergo restoration work. This process, especially for a wooden boat, involves extensive replacement of original material with new. Furthermore, since boats are naturally biodegradable, this process of replacement will continue indefinitely. Ultimately the museum is left with what is essentially a replica object occupying the space once filled by the original. This cannot be compatible with the purpose of preserving original objects for future generations to study and enjoy, and an essential link with the past builders and users is lost.

A frequent confusion arises from a lack of clarity. Without a Conservation Plan to help define exactly what the preservation task is, it is easy to confuse the preservation of original fabric and the preservation of the skills and craftsmanship that building a ship or boat entails. The preservation of fabric and the preservation of skills and operations are equally valid activities, but they are very rarely compatible.

Boat restorers inevitably make compromises and slight modifications as the work continues, and frequently the materials and systems used in the original are no longer available. The common defence proposed for this approach is that the restorer is merely continuing the traditional maintenance and repair process that the boat has always received. This is a dangerous argument. It must be recognised that bringing the boat into a museum context fundamentally changes the role of the boat and, unlike the amateur boat enthusiast, the museum must decide whether it wishes to preserve the object itself, or the traditional repair and rebuilding skills. The two are not compatible on the same boat.

Builder's marks, along with the signs of wear and tear associated with the use and function of the boat are often irretrievably lost in restoration. The process is akin to a museum trying to acquire an historic but at the same time 'brand new' boat, and it can frequently be seen in attempts to restore a boat to a particular date, usually to the day she was built. Yet boats were not created to exist at one point in time, but to serve for a lifetime. They are living evidence of changes to their form and function over the whole of their working life, and all of those stages are an essential and interesting part of the record, and of the display.

DISPLAY AND INTERPRETATION

The argument in favour of re-using boats is almost always coupled with a jibe at the fate of a boat which may have been consigned to the slow decay of a dusty and old-fashioned museum, particularly if the boat has been shown or stored outside. This can often be difficult to gainsay – not least because it has sometimes been only too true.

High-quality interpretation of boats is absolutely essential. Just as context and environment have been stressed in terms of collecting and recording, likewise they must figure largely in the display. It is not effective simply to place a boat inside a gallery and expect her to be understood. One national museum has already been quite successful in addressing the similar problem of displaying fish collections, with very realistic model fish inside model aquaria, set up so that not only can the public actually see the fish clearly at all times, but the fish are seen in particular guises or poses with the environmental context essential for their explanation. This applies to boats too. For example, it is impossible to see or understand the underwater surfaces of a boat when she is in the water. In a well-thought out gallery the underwater shapes can be seen and explained without losing sight of how a boat might float, and where she might operate. Various ingenious solutions, sometimes involving artificial water levels and mirror glass, have been used to achieve these goals.

Eventually, virtual reality systems may well become a standard method of interpretation. They will be able to provide, without threatening the original object in any way, experiences which in real life would not only be difficult and inaccessible, but often too dangerous to allow public access.

USAGE AND REPLICA BOATS

Displaying outdoors and even using ships and boats will not only slowly or quickly destroy the originals but also throw up the vital issue of safety. Safety in public access is paramount, but often means that either the public cannot be allowed to use a boat at all, or that the original boat has to be substantially modified to meet modern safety regulations. Where only museum staff and insured volunteers are able to demonstrate the boats, the result can be unsatisfactory. The visitor is often too far away to see or understand much and, in any case, can only see the upper half of the boat – the rest is under the water.

Safety is an issue for the boat herself. Every time a boat ventures onto the water there is always the possibility of accident or loss, especially if the restored boat is less stout than she was when first built. This risk must be considered when deciding on a programme of restoration and use. The tragic wrecking of the 19th-century historic ship *Maria Assumpta*, is a case in point. Marketed as the oldest square-rigged ship still sailing, she struck the Cornish coast in 1995, and sank quickly with loss of life.



A replica cutter built for HMS Victory in 1993, and used at various events.

© Brian Lavery

In the case of highly significant boats the museum could try and collect two! One to be restored or reconstructed, used and interpreted, the other to be preserved intact. The alternative is to build an accurate replica boat, and this approach is making an increasingly significant contribution to ship and boat preservation. It allows original boats to be conserved and displayed effectively, while allowing their operational aspects to be displayed on the water without risk to the original or to the operator. Local boat-builders are usually available and very willing to undertake replication tasks, and the resulting boats can also add important information about operating and handling the boat, which may not have been available in the original documentation. Paradoxically, the replica solution is often in fact cheaper than the actual cost of restoring the original.

DECISION-MAKING

A common problem faced by curators occurs when a boat is acquired because she once did, but now no longer, represents a specific type which the museum wishes to acquire. In order to display her as such, modifications and restoration may be sought. Great caution and wisdom must be applied here. This step is a very major curatorial decision and must be accompanied by extensive detailed recording of the boat before work is undertaken. Minimal intervention to the boat has frequently turned out in retrospect to have been the wisest course.

Similarly, it may be decided that a boat must be displayed afloat and used for interpretation. Again this is a decision for the curator to make carefully and record his or her reasons before any work is carried out. The worst scenario involves a museum rushing into restoration and rebuilding work without stopping to think and plan carefully what the boats are for and what the consequences of any action taken might be. It is not that some actions cannot be justified, but that every action must be justified from an ethical or other standpoint, such as by an evaluation of a boat's significance in a Conservation Plan.

So, given all these warnings, are there any acceptable solutions? To use a boat is to decide that she is expendable, and can be a perfectly valid decision. It may be made after due consultation to discover how many similar boats are in preservation, or even still in use. It may be made after deciding what sort of contribution the boat or her sisters has made to the community in cultural, economic, and/or technological terms. Assessing these criteria means assessing how significant the boat is, and it is this factor which determines whether a boat is expendable. Guidance on questions of significance can also be sought from the larger maritime museums, but it should be constantly recalled that our responsibility is to future generations as much as the present.

STORAGE AND ENVIRONMENT

Boats, particularly wooden boats, are very susceptible to the outside environment, particularly to fluctuations in relative humidity and to rainwater damage. Ideally, all boats should be stored and displayed in a controlled internal environment. No set relative humidity level is ideal but instead the priority is to achieve a stable level. Stability is required not only at RH monitoring points, but across all the surfaces of the boat. It is thus essential to ensure that the interior spaces and corners of a boat are well-ventilated to equalise the relative humidity levels. Sometimes this will require the addition of electric fans or perhaps windsails.



Part of the display of the National Maritime Museum, Cornwall

© National Maritime Museum Cornwall



A lost cause? A boat on the island of Nevis in the West Indies.

© Brian Lavery

Nevertheless, it is surprising what can be achieved just by putting a simple cover over the top. A cheap and cheerful roof will work wonders for the long-term survival of the vessel, and open sides to the structure can virtually guarantee good ventilation. This approach can always be recommended.

Ships also benefit greatly from simple protection from the weather. The best example is the 1824 frigate HMS *Unicorn* in Dundee which received a simple roof in the dockyard while she lay in reserve. Today that roof survives, and well over 90% of the ship does too.

BIBLIOGRAPHY

Kate Clark, *Conservation Plans in Action: Proceedings of the Oxford Conference*, English Heritage 1999

Austin Farrar, *Recording a Craft's Lines*, from *Mariners Mirror* vol 82, 1996, pp 216-22

SS Great Britain, *Conservation Plan for the SS Great Britain and the Great Western Dockyard*, SS Great Britain Trust. Bristol. 1998. Available for download at www.ssgreatbritain.org

Basil Greenhill, (Ed.), *Chatham Directory of Inshore Craft*, Chatham Publishing, London. 1997, reissued as *Inshore Craft, Traditional Working Vessels of Great Britain*, 2008

Basil Greenhill, *The Archaeology of the Boat*, A and C Black, 1976

James Semple Kerr, *The Conservation Plan*, National Trust of Australia, Observatory Hill, Sydney, NSW 2000. ISBN 1 86364 026 6

Eric McKee, *Working Boats of Britain*, London 1983

Arts Council England, MLA, ReSource, *Guidelines for the Care and Preservation of Large and Working Objects*

National Historic Ships UK, *Conserving Historic Vessels: v.3: Understanding Historic Vessels*, c/o National Maritime Museum, Greenwich, London www.nationalhistoricships.org.uk

5 TONNAGE MEASUREMENT AND SHIP REGISTRATION

BY DAVID MACGREGOR, HISTORIAN, ARTIST, AND AUTHOR

Tonnage was originally the charge for the hire of a ship at so much per ton or ‘tun’ of her ‘burthen’. ‘Burthen’ was the older term used to express the carrying capacity in the number of tuns of wine a ship could carry. A ‘tun’ cask could hold four hogsheads or 252 old wine gallons (‘burthen’ as a term gradually fell out of use over the course of the 18th century). On this tonnage figure all taxes and dues that a ship owed in port was levied, and it became a very important calculation for the ship. Various systems and formulae were developed over the years, and ship design was frequently directly affected by the changes in the formulae, in order to minimise the tax, light dues, and harbour fees payable.

A new system was promulgated in 1854. It calculates actual cubic area of the ship below the upper deck to give the gross tonnage of the vessel, in which one ton is 100 cubic feet. The net tonnage, upon which tax is paid, is calculated after due allowance is made for specific areas such as engine room and crew quarters. These are both known as Register tonnage figures, and they are measurements of volume, not to be confused with deadweight or displacement. For a merchant ship the deadweight tonnage is the actual mass of the cargo she can carry in order to load her down as far as maximum shown by the Plimsoll line marked on her side. Warships are measured in terms of their displacement, which is the actual mass of the ship herself, measured by the volume of water she displaces when afloat. Traditional yachts are often measured in Thames Measurement, developed by the Royal Thames Yacht Club in 1855 to avoid manipulation of the old rules when handicapping racing yachts.

When describing a ship, the tonnage figure often takes precedence over any other information but it is incredible that until 1836 the complex curved structure of a ship was only measured in two places in order to compute the tonnage. Two measurements make a flat, two-dimensional object not a solid, three-dimensional one. The length was indeed measured and so was the breadth. Those were the only two actual measurements that had to be taken. Various assumptions were made, the chief of which was that the depth equalled half the breadth. How convenient for the surveyors and for everyone involved! A simple multiplication sum of the length, breadth, and the assumed depth was followed by the division of the product by 94 and the quotient was the ship’s tonnage.

Between 1775 and 1875 three distinct and different systems of tonnage were in operation.

The one outlined above and latterly known as the ‘Old Measurement’ was in force until the end of 1835; from 1836 to 1854 the ‘New Measurement’ rule was employed; from 1855, and still in current use today, the system was that suggested by George Moorsom and specified in the Merchant Shipping Act of 1854.

The first English rule for measuring tonnage is probably that of 1582 and during the next two centuries it underwent various amendments, but in 1773 an Act was passed to prevent smuggling in which was embodied a more precise method of tonnage measurement than in previous regulations. His system was similar to the instructions issued by the Customs in 1719. At first the new tonnage rule only applied to vessels carrying spirits or hovering off the coast or to cases where tonnage had to be stated

officially, and it did not apply to colliers or certain fishing boats. However, by the ‘Registry Act’ of 1786 the tonnage rule of 1773 was adopted officially for every class of vessel and remained in force until the end of 1835.

In the length measured for tonnage by the rule of 1773, no after perpendicular is required. The main stem continues up to the underside of the bowsprit while the stem and knee of the head rake forward in a large overhang.

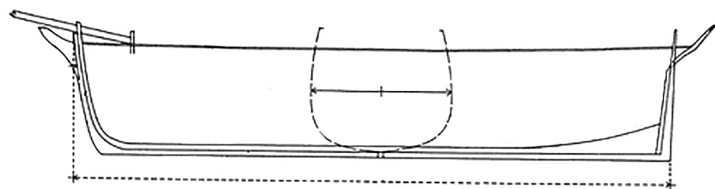
In the calculation, it was the length of keel that was used and this was obtained by deducting 3/5ths breadth from the length. So the formula appears as:

$$\frac{(L - 3/5 B) \times B \times 1/2 B}{94}$$

As pointed out earlier, the depth was not measured and was assumed to be half the breadth. It is most important to note that this depth is the depth of hold and not the draft of water. The divisor may have been obtained by selecting a large number of ships, listing their total tonnage, and then calculating a common aggregate. Alternatively it may be the result of tradition. The various dues chargeable for the use of port facilities were assessed according to a vessel’s tonnage.

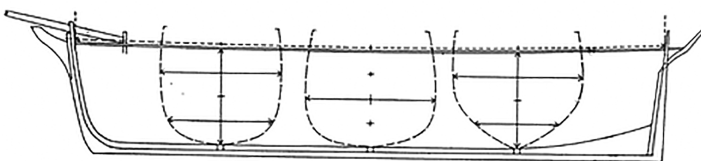
The Registry Act of 1786 fell within the range of the Navigation Acts because it was designed for the ‘increase and encouragement of shipping’. In addition to consolidating the method of tonnage measurement and stating what constituted British ships, it also extended the scope of the 1696 Plantation Registration Act, by establishing a permanent registry of all British ships of fifteen tons and upwards. The Custom House Registers of shipping, often referred to here and of immense value, date from the year 1786.

Following the inability of an Enquiry in 1821 to reach any practical solution for amending the rules of tonnage measurement, a second Commission was appointed in 1833. The scheme suggested by Edward Riddle of Greenwich Hospital appears to have been the basis for the Commission’s recommendation. It attempted to obtain the internal volume by means of three crude cross-sectional areas: ‘[t]he principle which guided the Committee in their selection was that a rule of such general application should depend on the smallest number of measurements necessary to give the figure of the hull, and that it should afford results sufficiently exact for the required purpose, by an easy arithmetical process’. For the first time, dimensions were taken in feet and tenths of a foot. The recommended rule was passed by Parliament in 1835 and became law as from 1st January 1836.



Old measurement tonnage. This diagram shows between which points the only two dimensions were taken.

Proposed 1821 tonnage. This diagram shows the first attempt at measuring the internal volume as proposed by the Committee convened in 1821



Old measurement dimensions

Under the new law which became known as ‘New Measurement’, the deck was divided into six equal parts between the after part of the stem and the foreside of the sternpost, and at the first, centre and last of the five points so obtained, a primitive form of cross-sectional area was measured internally, although the measurements only consisted of two breadths and one depth at each point. The actual method of calculating the tonnage is irrelevant here but a full account may be found in George Moorsom’s *Brief Review and Analyses of the Laws for the Admeasurement of Tonnage* (1851).

The paucity of measurements resulted in numerous attempts at evasion, and the publicly stated opportunities for this which Alexander Hall & Sons announced, eventually drew the attention of all to the urgent need for yet another reform in the mode of assessing tonnage. In Hall’s case, a new approach to fine-lined ships was the result.

Thus the ‘new measurement’ can be thanked for stimulating inadvertently a reappraisal of naval architecture and a radical alteration of hull proportions. It was found that a redistribution of the ship’s body into a shallower and longer hull permitted the same amount of cargo to be carried, yet reduced the actual register tonnage figure. Of course, this was an unintentional by-product of the new law.

The points between which the principal measurements were taken were now radically different from the old measurement rule, so that it was necessary to restate the definitions. Enclosed spaces above the level of the upper deck, such as the poop or raised quarterdeck, were also measured for tonnage for the first time. All new ships were measured in feet and tenths of a foot and appear thus in *Certificate of Registry*, in *Lloyd’s Register of Shipping* and in the survey reports. Existing ships did not have to be remeasured unless radical alterations were made to the hull or if the owner desired it. Thus the figures of old and new tonnage are quoted simultaneously for most ships until 1854, when the Moorsom system was introduced, and in many cases the two figures lingered on for another ten years if a ship had not been remeasured according to the Moorsom rule. In *Lloyd’s Register of Shipping*, the uppermost tonnage figure is usually that by the old measurement rule; the lower figure is according to the new measurement rule, and is often printed in a slightly smaller typeface. If only one tonnage figure is given, it will be the old measurement for ships built prior to 1836, but the new measurement for ships built subsequently. The new divisor in the calculations was 3500, which resulted in awkward fractions.

These instructions for measurement in the tonnage and registry acts are very sparse and liable to gross misinterpretation today, although contemporary surveyors doubtless received copious explanations. Technical language suffered from lack of precision and the writer in those days was virtually inarticulate when obliged to describe practical operations. The use of words, hitherto entirely adequate in literature, required redeployment by specialized writers who gradually asserted their mastery in this new medium and eventually created a new vocabulary.

The subject of a more correct method of measuring for tonnage had resulted in considerable discussion and in 1849 a third Commission was appointed by the Government to inquire into the matter and submit a more satisfactory rule. The Commission was made up entirely of practical men – shipowners, shipbuilders and naval architects – who believed that only by a careful measurement of the hull and the computation of the cubic contents, could an exact tonnage figure be estimated. But their proposals, based on a scheme by the naval architects William Parsons and George Moorsom, required external measurement in which offsets were taken at a number of stations and from them a curve of areas drawn to calculate the gross cubic content of the hull. This required considerable expertise that was incompatible with the nature of the work. It discriminated unfairly against ships with thick wooden frames and planking as against thin iron plating, because an iron ship would have a greater internal volume than a wooden ship of the same tonnage and could accordingly load a larger cargo. The

proposals were received unfavourably by the shipping industry and the Government declined to adopt the Commission's report.

But animated discussion continued, and the Board of Trade and other societies were bombarded with suggestions and proposals. Meanwhile a system of internal measurement was proposed by George Moorsom, who acknowledged in his writings that external measurement was not the correct answer. It was conceded by all that a thoroughly reliable and accurate mode of measurement must be adopted and one that acted indiscriminately on all classes of vessels, and Moorsom's proposals did just this. His scheme proposed the measurement of a series of transverse sections in the hold and, from the areas so obtained, the internal volume was calculated by Simpson's rule. The number of transverse sections varied between four and twelve depending on the length of the hull, and the areas were to be measured below the *tonnage deck*, which was defined as the upper deck, or the middle deck in three-decked ships. To the figure so obtained was added the volume of poop, forecastle, and deckhouses to produce a gross figure, and when divided by 100 the quotient was the tonnage. This divisor was deduced by dividing the aggregate tonnage of the United Kingdom in 1833 into the estimated cubic capacity of this tonnage. The answer was 98.22 or 100 for convenience. The choice of this divisor facilitated the calculations and meant that 100 cubic feet equalled one ton. George Moorsom's proposals were embodied in the Merchant Shipping Act of 1854 and have remained ever since 'the foundation of the tonnage registry laws and measurement rules of the maritime nations of the world'.

There were three tonnage figures: under deck, gross, and net register. Crew accommodation above the *tonnage deck* was exempted from inclusion provided it did not exceed one-twentieth of the gross tonnage; if it did, only the excess was to be included. This provision induced crew accommodation to be placed above the *tonnage deck* in a topgallant forecastle or large deckhouse so that there was no taxable space below the upper deck that could not carry cargo. For many years the gross and net tonnages of sailing ships were identical and in many cases that of the under deck tonnage as well. In 1854 the only permissible deduction from the gross tonnage total was the engine room in steamships. In 1867 a new law allowed crew accommodation, wherever situated in the hull, to be deducted from the gross tonnage figure, and from this year the net register tonnage of sailing ships could be less than the gross tonnage. Other deductions have since been allowed, such as master's accommodation and various store lockers. It is once again necessary to define the points between which dimensions were taken both for tonnage measurement and for registry and to illustrate these with diagrams for absolute clarity.

6 THE TOOLS AND TRADES OF SHIPBUILDING AND REPAIR

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INTRODUCTION

During the age of sail the construction of the wooden-hulled sail-powered warship was the most complex ‘making’ or manufacturing process undertaken in the pre-industrial world. In the larger naval yards it was an operation that involved up to 26 separate trades and large numbers of workers – for example during the 1750’s Royal Dockyards like Chatham employed over 1700 people. Private shipyards were generally smaller places employing much smaller numbers of people building merchant vessels. In times of war many such yards would also be employed in warship construction. The core shipbuilding trades (shipwright, caulker, mastmaker, rigger, sailmaker) were generally the same in both.

In the 19th century the impact of the new technologies of iron, steel and steam, together with escalating demand for ever larger merchant and naval vessels to satisfy the demand of Britain’s growing international trade and global trading position, led to the development of large private or commercial shipyards on a scale to rival the Royal yards. These were concentrated on, or close to, the major trading rivers such as the Thames, Tyne, Tees, Clyde and Mersey. New trades developed with the new technologies – trades such as boilersmiths, engine-fitters, and riveters. In the Royal Dockyards shipwrights took on the challenge of the new materials, becoming equally proficient at working in wood or metal. In the private/commercial yards this tended not to happen with the new metalworking trades taking on their role.

At the other end of the scale smaller maritime communities, making their living through fishing and inshore trading, spawned a myriad of small family run shipyards and associated trades, such as ropemaking and sailmaking. As a result every maritime community in Britain housed craftsmen working in ship and boatbuilding related trades and material evidence of their endeavours survives today in the form of the tools and other equipment that they used.

Many of the individual hand tools used by people engaged in the construction and repair of ships and boats and associated trades were generic tools of their period, or were those related to trades common in other walks of life, for example those of carpenters, joiners and coopers. For the purposes of this article I will concentrate on those hand tools or variants that were highly specific to the maritime world and are readily found in maritime collections or in the possessions of people who worked in those trades.

TRADES AND TOOLS - AGE OF SAIL

SHIPWRIGHT

The most numerous of the trades related to ship construction and repair (for example in October 1762, 725 of the 1700 people employed in Chatham Dockyard were shipwrights) Highly skilled artisans, they were engaged in all aspects of ship construction and repair from laying down the ship's lines in the Mould Loft to the construction of the ship's frame and its subsequent planking.

Tools most commonly associated with shipwrights are:

ADZE

Used to shape large pieces of timber, adzes are characterised by a long curved timber handle or shaft with a curved iron or steel head and the blade mounted at right angles to the shaft. In general use in relationship to wooden ship construction for hundreds of years (it features on the 17th century Arms of the Worshipful Company of Shipwrights), it remains in common use today within the historic ship and wooden boat community.



Adze, HTL274
©Chatham Historic Dockyard Trust

SHIPWRIGHT'S HAMMER

A distinctive long handled hammer with one pointed end. One of the main uses of hammers like these was just prior to a ship's launch when wedges were driven in under the keel to lift it off the blocks.



Shipwright's hammer HTL276
© Chatham Historic Dockyard Trust



Shipwrights at Chatham 'knocking up the wedges' immediately prior to the launch of an O-Class submarine. PHA7727
© Chatham Historic Dockyard Trust

TWO-HANDLED SAW

Used to cut timber – most shipyards would have one or more saw pits used to cut (or side) timber logs into timber baulks or planks. Smaller two-handed saws would have been used to cut timber alongside the ship being built or repaired.



Two-handed saw, HTL1210
© Chatham Historic Dockyard Trust

AUGUR DRILL BITS

Long drill bits used with a brace to drill holes through planking and frame timbers to take timber nails (trenails) or bolts made of iron or bronze.



Augur bit, HTL497
© Chatham Historic Dockyard Trust

TOOL CHESTS

Shipwrights also used generic woodworking tools including a wide variety of planes. The quantity of tools needed by each shipwright led to the construction of tool chests. In larger yards, these were often an object made by shipwrights during their apprenticeship.



Toolbox, HTL977
© Chatham Historic Dockyard Trust

CAULKER

A related trade to shipwright Caulkers were responsible for ensuring that ships were watertight. Using special (and very distinctive) hammers and irons they drove Oakum (unpicked old hemp rope) into the seams between the ship's hull and deck planks before sealing it with hot pitch. They were also responsible for caulking dry dock gates to keep the docks dry. On going maintenance to maintain watertight integrity required seams to be regularly recaulked – especially those on the upper decks. Very specific and readily identifiable tools were created for both tasks in the form of caulking hammers and irons used to hammer the oakum into the seam; rakes used to extract old pitch and caulking prior to repairs; and pitch ladles used to pour molten pitch neatly along the seam. Often caulking tools were carried in specially designed tool chests which also doubled as a seat for the caulker. Caulking hammer and irons also appear on the Arms of the Worshipful Company of Shipwrights.



Caulker's box and caulking irons HTL497

© Chatham Historic Dockyard Trust



Caulking Hammer HTL276

© Chatham Historic Dockyard Trust



Caulking Iron HTL238

© Chatham Historic Dockyard Trust

SAILMAKER

Another maritime trade that has left its mark in the form of a readily identifiable tool of the trade is that of sailmaking in the form of the sailmakers' leather palm designed to fit over the thumb and protect the sailmakers palm from the needle when pushed through thick canvas. Other sailmakers tools include small fids – tapering cones, generally made of hardwood used when splicing rope and

marlin spikes which performed the same function but were made of iron and steel. Like caulkers, sailmakers developed their own type of seat, generally in the form of a long low bench. At Chatham Dockyard the tradition developed for these to be personalised with carpet!



Sailmaker's palm HTL1106
© Chatham Historic Dockyard Trust



Sailmaker's bench
© Chatham Historic Dockyard Trust



Sailmaker's pricker HTL1105
© Chatham Historic Dockyard Trust



Marlinspike HTL1105
© Chatham Historic Dockyard Trust

RIGGER

Like sailmakers riggers also used fids and marlin spikes, but often in much larger sizes – one of the largest being this ‘admiral’s fid’ recovered from the 1758 wreck of *Invincible*.



‘Admiral’s’ fid recovered from the 1758 wreck of the Invincible, Invincible collection INV153
© Chatham Historic Dockyard Trust

The process of worming, parcelling and serving the ropes which made up the ships standing rigging (the ropes that held the masts aloft) to wrap them in smaller rope (worming), canvas (parcelling) and marlin twine (serving) also produced a very distinctive and specialist tool – the serving mallet. Despite the name they were not used in the manner of a normal mallet or hammer – but were used by riggers as a form of lever to ensure that the outer layer of twine was wrapped as tightly as possible around the parcelled shroud.



A well-used serving mallet HTL 1295
© Chatham Historic Dockyard Trust

Riggers benches - generally made of heavyweight timber construction, perforated with numerous holes and mounted with a hand-operated vice - were also common sights in larger rigging shops.

IRON, STEEL & STEAM SHIPS AND SHIPBUILDING

From the mid-19th century the new materials of iron and steel and new methods of propulsion powered by steam began to enter the maritime world. Shipyards building larger merchant and naval ships became much larger and the home to new types of machines and equipment. In general terms few machine tools used in shipbuilding were different to those used in other areas of heavy engineering – apart from in one aspect – size!



These 42ft plate bending rolls (made by Hugh Smith & Co, Possil Engine Works, Glasgow in 1913) were used to bend armour plate and steel for submarine hulls at Chatham Dockyard until its closure in 1984. This equipment weighs c 200 tons!

© Chatham Historic Dockyard Trust

Large machine tools readily identifiable with shipbuilding and repair include:

Punch and shears – they were developed during the 19th century to undertake two processes needed when preparing iron and steel plates for use in riveted construction – on one side is a shear to cut the plate and on the other is a punch to make the holes for the rivets.



Punch & Shears – the punch is on the left hand side – the shears on the right

© Chatham Historic Dockyard Trust

Steam Hammers – used across heavy engineering, they were particularly common in shipyards and often present in large numbers.



Steam hammer

© Chatham Historic Dockyard Trust

Even common machine tools such as lathes were developed into specialist maritime related tools, some of the largest being those made to turn propeller shafts which needed to be able to accommodate large diameters and long lengths.



No 8 Machine Shop at Chatham Dockyard – a propeller shaft lathe dominates the top right hand corner of the workshop.
PHA9486

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