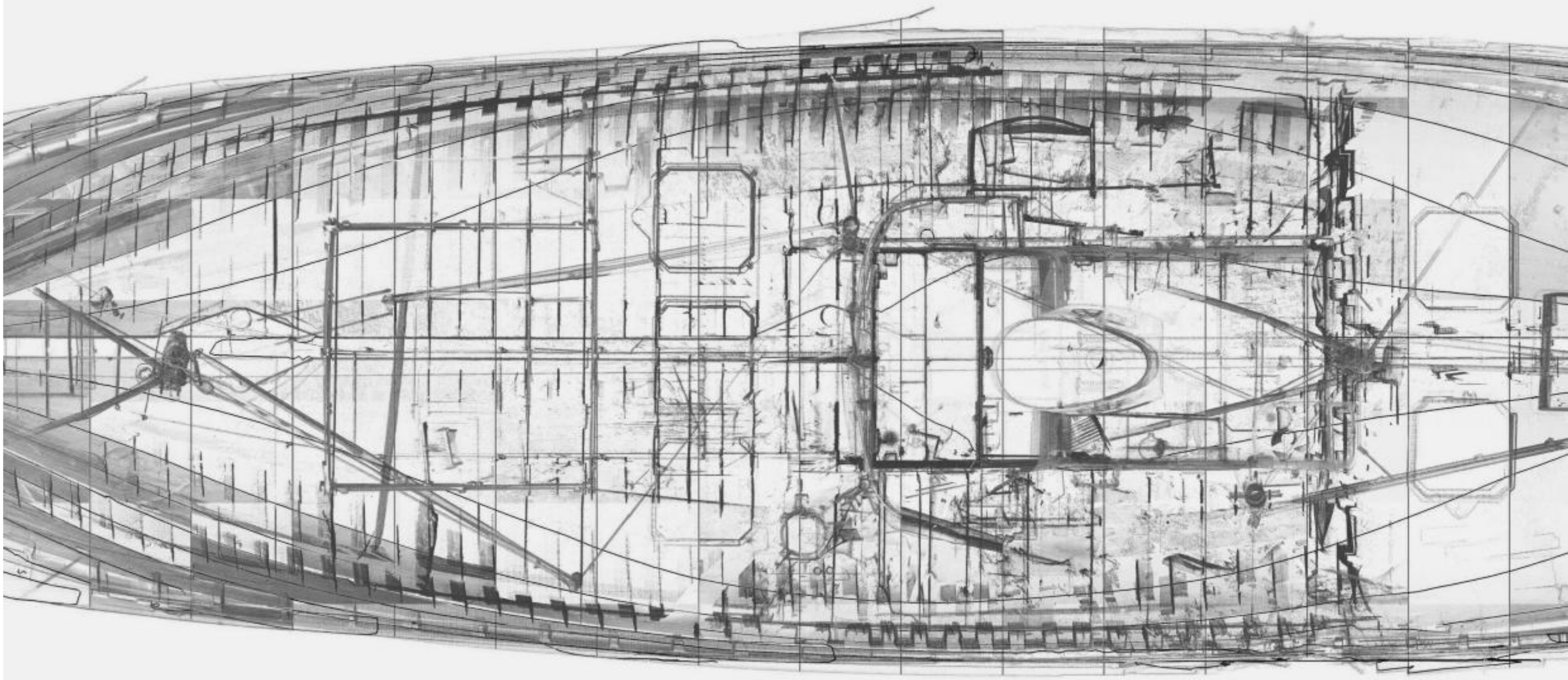

RECORDING HISTORIC VESSELS

UNDERSTANDING HISTORIC VESSELS **VOLUME 1**

ACKNOWLEDGMENTS

First Edition: 2007

Authors: Eric Kentley, Simon Stephens, Martyn Heighton

Commissioned by: the Advisory Committee on National Historic Ships

Second Edition: 2020

Author: Eric Kentley

Commissioned by: National Historic Ships UK

With thanks to members of the National Historic Ships UK Council of Experts for their advice and editorial comment; John Kearon for his detailed contributions on recording techniques and individual case studies; Stuart Norton for his expertise on photogrammetry; Windermere Jetty for assistance with the *Mary Anne* case study; José Manuel Matés Luque and Oskar Moral Goirigolzarri for providing the *Antxustegi* case study.

Cover image: Oskar Moral Goirigolzarri

FOREWORD

When the Advisory Committee for National Historic Ships was formed in 2006, one of its first actions was to commission the three volume series *Understanding Historic Vessels*, covering the key topics of how to record, conserve and, in the worst case scenario, deconstruct a historic craft to maintain its significance. The principles set down in these guidance manuals raised the bar in terms of best practise, established greater consistency across the sector and developed a set of definitions by which vessel custodians, heritage professionals, funding bodies and government officials could determine the level and type of intervention carried out in any heritage project.

It is now 13 years since the publication of the first two volumes and I'm delighted with the way in which all three documents have been received and adopted, becoming seen as the new standard for historic vessels, not just in the UK, but overseas as well. However, during this time, technology has moved apace and there are now new, improved methods for recording a vessel which must be considered. These enable us to capture not only sufficient data to build a fully accurate replica, but also to make the ship accessible in virtual form once it has gone.

As part of our *Forward Plan 2019-2023*, we pledged to revisit and update *Recording* and *Deconstructing Historic Vessels*, to incorporate the latest methodology alongside a series of practical case studies. The inclusion of this piece of work as a priority in our 5-year plan reflects the challenges we face as a nation in managing vessels at risk, with no legislation in place to protect craft on the National Registers from loss and increasing pressures on custodians as a result of the economic climate.

In these difficult times, it is more important than ever that the principles in *Understanding Historic Vessels* are adhered to wherever possible to safeguard vessel significance. For those craft which it is deemed unviable to keep after every option has been explored, deconstruction should be seen as a positive solution which enables us to retain the best possible record of the vessel, along with any significant parts, rather than losing the entirety to scrap.

I hope the new editions of these volumes prove useful and, if they help guide the nation's surviving historic vessels into a new era, capturing a virtual image of any which can't be physically saved, we will have achieved our aim.

Hannah Cunliffe, Director, National Historic Ships UK

ABOUT NATIONAL HISTORIC SHIPS UK

National Historic Ships UK (NHS-UK) is an independent, expert body funded by the Department for Digital, Culture, Media & Sport to provide objective advice to UK governments and local authorities, funding bodies, and the historic ships sector on all matters relating to historic vessels.

It is the successor to the Advisory Committee on National Historic Ships, established as a non-departmental advisory body in July 2006. In turn, that organisation followed on from the National Historic Ships Committee, which emerged from a seminar held in 1991 to discuss the problems facing the conservation of historic ships and vessels in the UK and the evident neglect of this important part of our heritage.

NHS-UK has a wide remit, looking not only at the immediate issues concerning historic vessels in the UK, but also addressing questions relating to their supporting infrastructure and potential to contribute in the wider economic, social and community context. It maintains the National Historic Ship Registers, which comprise: the National Register of Historic Vessels; the National Historic Fleet; the Overseas Watch List; the National Archive of Historic Vessels; and the UK Replica List.

The three-volume guidance publication *Understanding Historic Vessels* has been produced to highlight the main considerations in relation to the long-term conservation of vessels. This first volume, *Recording Historic Vessels*, suggests methods for creating a record to ensure the essential characteristics of a vessel are captured, and for holding this information in formats that are accessible and, given present knowledge, future-proof.

Volume 2, *Deconstructing Historic Vessels*, comprises a set of guidelines describing the steps to be taken leading up to the careful dismantling of a historic vessel which has come to the end of its days, how to explore every option before adopting this approach and what to do with the information (and in some cases recovered parts of the ship) emerging from this process.

Volume 3, *Conserving Historic Vessels*, explains the key principles behind conservation, helping specialists and non-specialists alike to develop an understanding of their project, its significance and select the most appropriate conservation route to adopt.

The volumes recognise the complexities of historic vessels and the differing circumstances of private owners and small trusts from those of larger charities, major museums, and national organisations. The approaches described are aimed at custodians of all kinds and take into account financial limitations that may preclude the use of extensive professional advice. These guidelines aim to be practical and achievable to encourage all owners to apply them at an appropriate level. Although the guidance has been specifically designed to address the needs of vessels on the National Register of Historic Vessels, it is relevant for owners of any traditional craft, large or small.

To see the full range of services offered by NHS-UK or find out how to obtain copies of Volumes 2 and 3, visit www.nationalhistoricships.org.uk

CONTENTS

SUMMARY

This booklet sets out ways of creating a permanent record of a historic vessel, to produce both a detailed history of her life and a snapshot of her present state. Such a record not only allows the significance of the vessel to be appreciated by generations to come but also enables informed decisions to be made about her long-term conservation and short-term maintenance.

The range of historic vessels in the UK is immense, from battleships to barges. This is reflected in the variation amongst owners, from government funded museums to private individuals. The guidelines here attempt to appeal to both ends of this spectrum. Of course we recognise that for the small organisation and the individual some of the techniques recommended will be unaffordable, but our objective is to provide sufficient choice of techniques that every custodian can find guidance on the most achievable level of recording for their vessel.

Chapter One explains why gaining and retaining a detailed understanding of a craft's significance should be the primary objective in recording a vessel and is followed by suggestions for investigating her history. A full examination of existing records will determine the level of recording required and the subsequent four chapters each deal, in increasing complexity, with methods for physical recording. Finally, guidelines are provided on how to store records on different media to ensure the longest possible survival.

When time and resources are short: five key actions to record your vessel

1. compile the most comprehensive vessel history possible (see pages 10 –13)
2. undertake a photographic survey, if possible extensive enough to allow photogrammetry at a future date (see page 18)
3. take basic measurements - length, beam, depth
4. measure a midship section (see page 22)
5. secure a permanent home for the record (see page 37)

1. UNDERSTANDING HISTORIC VESSELS

Historic vessels are conserved for many reasons. They can be beautiful objects and expressions of the shipwrights' art; they can be representatives of significant technological advances, or fine examples of a particular development in ship and boat design; they can be reflections of social or economic factors; they may have associations with heroism, famous incidents, notable people or with particular geographical areas. Whatever the reasons for their survival, vessels are material evidence of history and carry within their fabric information about their methods of construction and use, their careers, the phases of their development, their relevance today and their conservation needs.

There are also occasions when the continued existence of a vessel is no longer viable: she may be too dilapidated to be conserved, or there is no one willing to take her on. Yet the information she holds is important, and to lose her without retrieving this data would be not only to miss a unique opportunity of preserving her stories but also the chance to broaden our wider knowledge about historic vessels and to retain that information as a record for future generations.

The National Register of Historic Vessels (NRHV) lists those ships and other vessels that meet certain criteria (see Appendix C) which identify them as being of importance in the maritime history of the United Kingdom. It is essential that there are practical ways by which their heritage merit can be recorded and understood, and that the resulting information is held in an accessible form. This is particularly so for the vessels forming the National Historic Fleet, which are considered of outstanding national and regional significance.

1.1 Understanding significance

Understanding the ways in which a vessel is significant is fundamental to assessing her relative historical importance. Not only that, it is the foundation of all decisions that will be made about her, from the suitability of modifications, to fully developed conservation plans, from decisions about whether and how the vessel should be operated to how she should be recorded. (This is explored more fully in *Understanding Historic Vessels Volume 3: Conserving Historic Vessels*.)

A proper understanding of the significance of a vessel can only be attained through in-depth research that allows a critical appraisal of:

- whether the vessel is unique or typical in terms of her type and function (for example, is she the last surviving example, or a one-off design?) and how she fits in a national and local context (for example, the last type of fishing boat to be built in a particular yard, last of her type to trade / operate in her locality or a lifeboat involved in a famous rescue)
- the vessel's contribution to a broad understanding of maritime history (for example, a nineteenth-century warship illustrates much about the practicalities of fighting at sea)
- the vessel's contribution to technology, including her handling characteristics (for instance, the sole surviving example of a particular type of propulsion unit, a once-common pleasure steamer, an important variation on a construction method, or a typical gaff-rig)
- the vessel's contribution to social and economic history
- any parts of the fabric, fixtures and fittings that are unique or rare survivors or are typical of the type of vessel under consideration; or are of technological, social or economic importance

Historic England's *Conservation Principles, Policies and Guidance* sets out a number of areas to consider, which can be condensed into the following headings:

History	What does the vessel tell us about how people lived, worked, socialised or behaved? Does the fabric or condition of the vessel tell us anything about its history? Is she associated with important historical events? Is she associated with important historical figures, a notable shipbuilder, a naval architect, engineer or other maker? What is her provenance?
Technology	What were the methods used in the construction of the vessel? Were these methods rare or common? Is she an example of innovation? Is her power plant unique, or a rare survivor?
Social values	Who cares about her (other than you)? Is the vessel a memorial or a commemoration of some kind? Does she have any symbolic value? Is there a strong local association with the vessel? How is this expressed?
Aesthetic values	Would most people consider her beautiful? How is this reflected in her shape and form?
Rarity	How many other surviving vessels are like her? What are the differences? Among her type, is she significant? Where are the other examples? Are they more or less accessible to the public than your vessel?
Integrity	How much of the vessel's fabric is 'original' to its creation? What additions, repairs, modifications have been made before it came into your ownership or the public domain? (These modifications may also tell interesting stories themselves.)

Research into the vessel's history will generate a considerable amount of information, but it is essential that this is distilled into a summary of conclusions explaining what is significant about the vessel. Put into writing, this is a Statement of Significance, a form of document that is widely used throughout the heritage sector, as the foundation for all conservation plans (and frequently, funding bids too).

Remember: a Statement of Significance is not simply a condensed history of the vessel – it is an objective assessment of the vessel's heritage merit.

NHS-UK's template for setting out the Statement of Significance consists of three questions:

1. What is the vessel's ability to demonstrate history in her physical fabric?
2. What are the vessel's associational links for which there is no physical evidence?
3. How does the vessel's shape or form combine and contribute to her function?

We recommend that the statement is kept to one side of an A4 page, and not more than two sides, as this will concentrate the mind on really significant elements. This will also help third parties, such as funders, to understand at a glance why the vessel should be conserved. It may be helpful to write an extended statement first giving more detail, which can then be condensed into a shorter, more concise document.

For further information on writing a statement of significance, read Chapter 5 of Volume 3 *Conserving Historic Vessels* and download the NHS-UK's leaflet at www.nationalhistoricships.org.uk/page/statements-significance.

2. RESEARCHING A VESSEL'S HISTORY

A statement of significance can only be finalised once the vessel's stories and its fabric are fully understood. While some historic vessels are conserved for their aesthetic appeal, all are conserved because of their associations with the past. These may be links with people, places, exploration, battles, trade and other economic activities, technological innovation or any combination of these. To understand these and their importance requires a detailed knowledge of the vessel's history throughout her life, from first concept to her physical state today.

NHS-UK strongly urges all historic vessel owners to undertake the research required to compile an accurate and complete record of the vessel's history, not as an academic exercise but as an essential step in understanding and sharing the significance of their craft.

2.1 On-board ship research

Research should begin on board the vessel with a careful study of the fabric. An intimate knowledge both of how the vessel is constructed, powered, fitted-out and arranged, and of how she has been repaired, modified and altered is invaluable for assessing the usefulness of the material that will be uncovered in documentary and other research. Even if you intend to record the vessel by one of the methods described in later sections in this volume, these are simply means of capturing shapes and features. There is much more to a vessel than these.

We recommend starting research by writing an extensive description of, so far as can be established:

- general shape and rig
- propulsion system(s), including details of engines, propellers, etc.
- overall dimensions (length, beam, depth)
- construction method, with enumeration of key elements (frames, stringers, etc.)
- materials used including metal and timber types if they can be identified with certainty
- equipment and other fittings
- evidence of repairs

- evidence of changes to the vessel's structure or general arrangements
- evidence of damage
- tool marks

The description should be primarily concerned with the vessel's current form rather than any former layout, although where there is evidence of earlier features (for example, marks on decks), this should be recorded. It should be limited to only the physical evidence of the vessel.

Photographs should supplement the description. However, in some circumstances, sketches, even rudimentary ones, showing specific details can be a better recording medium than photographs: this is standard practice in the recording of buildings where the recorder wishes to emphasise details which a photograph cannot highlight. The eye is more selective than any camera and a good annotated sketch can often be an effective memory jogger. This may be particularly helpful where there are awkward angles of vision, or there are so many features to record that they become difficult to differentiate in a photograph (a profile comb can be invaluable to record and draw the intricate shapes of mouldings in the more highly finished vessels). All such sketches should be annotated and eventually cross-referenced with the results of the other recording methods.

One aspect often overlooked, and which will not necessarily be captured accurately in photographs are the colours of the vessel, internally or externally.[1] Most cameras are very unreliable in capturing a good colour match. A spectrophotometer is one solution, but good hand-held versions currently cost around £1,000 and above. Other options include capturing a good colour match with coloured pencils, watercolours or crayon, or comparing colours with Pantone charts[2] which have become a universally-recognised colour matching system. Don't forget to capture colours where the current paintwork has been chipped away, revealing earlier paint schemes.

[1] There are for example many webpages devoted to debating 'White Star buff', the colour of the line's funnels, because the exact shade of white/yellow/beige was seemingly never recorded.

[2] At the time of writing Pantone charts cost around £140. Although they are available online, unless you have a colour calibration device for your monitor, screens cannot be relied upon for accurate colour representation.

2.2 Plans, photographs, documents and articles

Valuable resources include builders' plans and lines drawings; surveys; bills of lading; repair invoices; logbooks; diaries; letters; newspaper and journal articles; books; contemporary photographs; film and video footage; models; photographs of past conservation work; and ship portraiture. The research should not focus solely on the vessel's working life in the role for which she was built, but consider her entire operational career and beyond. The vessel may have a significant phase in later life and this can also give clues to her current appearance and other associations.

Many historic vessel owners already have extensive historical information on their vessel but you should nevertheless satisfy yourself that you have explored all reasonable possible sources. Much investigation can now be carried out online – archives in particular are well catalogued[3] and the British Newspaper Archive[4] allows access to hundreds of local papers. Lloyd's Registers for 1930-1945 have been digitised as part of the Plimsoll ship data project[5] by the Southampton City Libraries and Archives Services in conjunction with Lloyd's Register's Heritage & Education Centre. The fields can be searched by ship name(s), year of build and by gross tonnage. The Associations of Yachting Historians has also now digitised Lloyds Register of Yachts and the complete run can be purchased on a USB stick for a fee. If you know your vessel's builder, L.A. Ritchie's *The Shipbuilding Industry: a guide to historical records*, even though published in 1992, remains the best source for locating where any plans or other records may be preserved in archives and museums.

The University of Exeter has an online finding aid, ELMAP, which is a catalogue of maritime sources in local archives in England and Wales: https://humanities.exeter.ac.uk/history/research/centres/maritime/resources/elmap/

In addition, the National Archives has a webpage dedicated to helping you find your local archive: https://discovery.nationalarchives.gov.uk/find-an-archive.

You should also check NHS-UK's registers for similar craft.

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[3] Searches on The National Archives website can locate records in local archives as well as at The National Archives itself – nationalarchives.gov.uk.
[4] https://www.britishnewspaperarchive.co.uk. This is not a free service but can be accessed by a subscription or pay-as-you-go.
[5] https://southampton.spydus.co.uk/cgi- bin/spydus.exe/MSGTRN/LOCAL/BSEARCH?HOMEPRMS=GENPARAM

Perhaps understandably, few archives or museums as yet have catalogues of their plans collections online and an email enquiry will be necessary. Plans are of particular importance in determining the shape and layout of a vessel at a particular moment (usually construction but sometimes for a proposed modification). A lines plan (known in earliest times as a draught) is the most useful way of reconstructing hull shape and for analysis of performance, but they give little clue to the internal layout of a vessel: these are found on general arrangement plans. For some vessels, construction plans survive, such as framing and planking plans, as well as rigging plans.

Your research is likely to result in the accumulation of an enormous quantity of material, in a variety of formats. For it to be useful as a permanent record, it is essential to compile an index of the information that summarises:

- what type of information it is (e.g. a lines plan, or group of photographs taken on a specific date)
- what the information is about
- the date the information was created (if known)
- where you have stored the information
- whether you hold the original or a copy

It is often not practical or possible to keep the original versions of all the available information. Where information is held elsewhere, the index should note:

- where the original information is held (e.g. a local records office)
- the information holder's reference number
- whether you have a copy of this information (and if so, where)
- the date the information was seen and the name of the person who saw it.

2.3 Collecting memories

Interviewing past and present owners, crew, harbour workers, passengers, etc. can reveal much, particularly about a vessel's operational life which is otherwise unlikely to be captured. As well as their intrinsic value such interviews may also lead to previously unknown documentary sources.
Although it is tempting to chat casually with interviewees and note

things you find of interest, if you record your interviews and preserve them, they will be available to future researchers, whose interests may not be the same as yours.

We recommend that you approach interviewing formally, as an oral history project, so that before an interview takes place the purpose is defined and explained to the interviewee. The interviewees should also understand who will be able to listen to the interview and how it will be preserved. Consequently, they should be reminded to be careful of slander and defamation. Copyright laws are complex in this area, so a sensible measure is to obtain a signed agreement allowing you to use the interview. A draft agreement is set out in Appendix B. General Data Protection Regulation is another potential minefield – you should avoid collecting any personal data about the interviewee other than that revealed by the interviewee in the course of the interview.

Prepare for interviews by having an overall plan, with topics grouped logically. A list of open-ended questions will keep the interview going, but give the interviewee room to develop their answers.

There is a wide range of equipment available for audio recording. It is possible to obtain an acceptable quality using a smartphone but their internal microphones (usually located at the bottom of the phone) are generally poor, so it is worth investing in an external directional microphone (and, for outdoor recording, in a windjammer – in this context a fur cover designed for wind-noise isolation).

Smartphones generally have a pre-installed app for voice recording, but there are other free or inexpensive apps which give you greater control over the sound quality. For example, the free Sound Recorder Hi-Res for Android will allow recording in the lossless FLAC format and Hokusai Audio Editor will allow recording in the lossless WAV format (see Section 8.5).

Before you begin, make sure you have enough memory to record by looking at Settings/General/Usage. As a rough guide, one gigabyte on your phone will allow you to record 100 minutes in WAV format.

3. DETERMINING THE APPROPRIATE LEVEL OF RECORDING

As your research progresses, the extent to which the vessel's significance relates to her shape, her construction, her interior arrangements and her fittings, or any one of these aspects will emerge. For example, the primary significance of a small ferryboat may be her role as a vital transport link and she may have no technological or aesthetic significance: if builders' plans exist or other similar craft survive, it may not be necessary to record her shape and construction in great detail: time would be better spent uncovering her social history. However, an experimental craft's significance may be almost entirely derived from her shape and structure, so her current shape and structure must be recorded and checked against any historical information.

Ideally, the information acquired during the course of the research should be sufficient to enable a replica or a model to be built that is accurate in all essential details, from scantlings and frame shapes to materials and paint schemes. This does not necessarily mean that a full survey of the vessel is required. Your research will have located any surviving and available lines, construction or rigging plans, surveyor's drawings, etc. as well as examples of similar vessels (both surviving and lost) for which plans can be found. But even if a good record of your vessel already exists, you should still ask:

- are these plans, supplemented with the other information you possess, really sufficient to enable an accurate replica to be made?
- has the vessel been modified in a significant way from that depicted in the information?
- has the vessel become distorted so it is not actually possible to establish whether the information truly represents the vessel?

Don't assume that existing plans are accurate, or reflect the vessel's current configuration. However, they can be used as a baseline check and, by comparing key dimensions and noting structural differences, additional, replacement or missing fittings, etc., it is possible to greatly reduce the amount of new recording work needed.
In addition to the importance of the shape and construction to the significance of the vessel and the existence of plans, four other factors will determine the level of recording that is achievable:

1. money: a full professional survey to create construction plans will cost thousands of pounds for large vessels: this is out of the question for private owners and smaller hard-pressed trusts.
2. time: measured surveys, particularly when undertaken by those who do not do such work for a living, are very time consuming. There may also be external constraints and pressures that limit the time available for recording: for example, a vessel may be out of the water for only a few days, and a large vessel will obviously take considerable time to record.
3. the physical state of the vessel: a dilapidated vessel may have become severely distorted and thus more complicated to record (although it may make certain construction features more accessible).
4. location of the vessel: vessels are much easier to record out of water rather than when they are afloat.

These factors, combined with a knowledge of existing information on the vessel will help determine which of the four principal methods of recording a vessel is most appropriate:

- photographic survey, the quickest and simplest method of recording
- measured drawing, taking dimensions from the vessel with the aim of drawing up plans
- photogrammetry, which uses a computer program to interpret photographs and create a digital model of the vessel
- laser scanning, which uses lasers to measure distances to millions of points on the vessel's surface which can then be used to create three dimensional models and plans.

You should record your reasons for selecting a particular method (the Future is always asking "Why didn't they think of …?"), the equipment used and its specifications, and a description of how and when any recordings were carried out, by whom and what limitations were encountered.

3.1 Engaging a surveyor

The larger and more complex the vessel, the greater the desirability of engaging a professional surveyor. The surveyor could be a naval architect, a marine surveyor, an archaeological surveyor or a building surveyor but the inclusion of master craftsmen such as shipwrights,

boilermakers, and platers as part of the survey team can also be of great assistance in understanding and recording vessel type and construction.
Surveyors will generally offer one of three recording systems or a combination of two: laser scanning, photogrammetry or measured surveying, all of which are discussed below. As well as the issue of cost, the selection of a surveyor should be based on:

- guarantees of accuracy of the completed survey. For professional systems, guarantees should be +/- 6 mm over a range of 50 metres
- the format of the completed survey (for example, a set of vector drawings in a common software format)
- experience with surveying maritime craft
- experience in using computerised scanning methods
- membership of appropriate professional organisations

When seeking a suitable surveyor, consult the National Directory of Skills and Services at www.nationalhistoricships.org.uk/shipshapenetwork or contact the NHS-UK team directly for further guidance.

Some surveyors will offer to retain the digital data on their own systems and produce specific plans on request, but this should be avoided. This would give the surveyor a monopoly in producing plans for you, which could become costly and there may be no guarantee that the data will be kept safely and in perpetuity. It is better to organise the safekeeping of the data files yourself, even if you do not have the software to use them.

Regardless of their experience, it should not be assumed that a professional surveyor can provide the information required without a detailed brief. Best practice is to discuss an outline brief with your chosen surveyor (or with several if you put the work out to tender) so that all relevant issues are covered and all parties understand the nature of the recording work to be undertaken. The final contract should set out exactly what is required as the end product or products.

Risk assessment

Afloat or ashore, it can be hazardous to record vessels and before any work begins, it is worthwhile spending time assessing risks that might be encountered and what you can do to minimise them. A generic risk assessment form is included at Appendix A to assist those undertaking the recording exercise themselves. Professional surveyors should carry out their own risk assessment in consultation with the custodian and be aware of the potential hazards involved.

4. PHOTOGRAPHIC SURVEYING

4.1 Media

There are still many aficionados of traditional black and white film, supplemented by colour slides to identify paint schemes, for recording but for convenience and economy, and for the ability to use the images for photogrammetry, digital photography is preferable. Even cameras on some mobile phones are capable of producing very high-quality imagery. However, a camera with control over focussing and focal length, with a larger sensor than a mobile phone possesses is preferable. As a rough guide, individual images should be three megapixels or more in size.

It is important to have a lens that does not distort significantly, and not to use a fish-eye lens unless there is no other way to record a tight space. If the camera has a zoom facility, this should not be used except for exceptional recording of small details: the primary set of images should all be taken with the camera on a fixed focal length, otherwise this may restrict how the images can be used in other applications (such as 3D modelling). The specification of the lens should be noted as this information may be required for some of these applications.

Most phone cameras use JPG (previously known JPEG) as the default file format. Unfortunately, every time a JPG is saved, renamed or moved it is compressed again, losing something of the original quality. Therefore these images will eventually need to be saved in a different format (see Section 8.7). The preferred format for shooting is RAW, which captures far more detail than any other format and does not degenerate.

4.2 Method

Before beginning the photographic survey, devise a logical route around the vessel, for example, from bow to stern on the starboard side, and stern to bow on the port side externally and then following the same pattern on each deck.
Establishing a simple numbering system that identifies the locations where images are to be taken can be helpful for future reference – for example a point on the lower deck on the starboard side at the fifth viewing station looking aft could be numbered LD_STB_5A. Not only will this mean you are not tempted to take random and unnecessary

shots but also you can later use the number as the filename for the digital image. Make a note of your system in your records.
Even if you have no immediate intention to use your images for photogrammetry (see Section 6 below), someone else may want to. Therefore, it is worthwhile following the photogrammetry conventions if this is practical:

- hold the camera in the portrait position to capture more height
- for both external and internal shots, walk around the vessel and shoot from different positions and where necessary take a high, straight and low shot in each position. Do not stand in one spot and rotate the camera
- aim for at least a 60 per cent overlap between one image and the next: remember to make sure there are at least two images taken from different angles of every feature
- the more pictures the better, even though it makes cataloguing more time-consuming
- use good lighting and avoid flash
- do not use fish-eye or ultra-wide-angle lenses
- use a tripod (and think about whether a photographic pole mast, to take photographs at a height, would be useful)
- keep the focal length, focus, ISO and aperture consistent for best results. Shoot in ‘aperture priority mode’ and set the aperture between f/8 and f/16 with a low ISO setting to reduce the graininess of the images
- don’t crop any photographs.

If time is particularly short, consider using digital video. You can take overall context views, from which still images can be obtained if required. Video is of course the best way of capturing a vessel in operation.

5. MEASURED SURVEY

Undertaking a measured survey is challenging but immensely rewarding. Unlike a photographic survey, where one is concentrating on the image, a measured survey forces you give your attention to the vessel, often observing features that you have never noticed before.

Your written description of the vessel is almost certain to need expanding with scale drawings of parts or even of the whole vessel. If she has features of particular significance – for example, accommodation arrangements or a unique bridge configuration – these should be measured and drawn up. Relatively small areas can be accurately measured with tapes and plumb bobs. Hand-held measuring lasers are now relatively inexpensive, as are laser levels which project perfect vertical and horizontal lines to measure to and from. Indeed, up to a point, it is possible to measure the hull of a vessel with relatively simple equipment.

However, that point occurs when the vessel's length is more than around 15 metres: if she is longer than that, it is not practical to survey the hull without resorting to professional surveyors and the equipment they have at their disposal.

If your vessel is less than 15 metres and no plans for her have survived, you should consider at least recording the midship section. This should be measured outboard if the vessel is ashore and inboard if practical to show the thickness of the hull (and how this may vary), the disposition of the decks (including any camber) and the location of longitudinal elements such as stringers. Again, on relatively small vessels, this can be undertaken with common measuring equipment.

If you are undertaking this or a more extensive survey of the hull yourself (or, better, with a few colleagues), we recommend you first undertake a trial to assess whether you can achieve an acceptable degree of accuracy. This might be capturing the external midship section. It should be measured and drawn twice. The results must vary by less than 5mm in a metre: if this cannot be achieved, and you are not confident that the accuracy can be improved and kept at a consistently high level, you should consider either engaging a professional surveyor or using alternative methods of recording (such as photogrammetry).

For measuring the midship section and for surveys of the entire hull, there are fundamentally two approaches:

a. ‘shorthand’ method, where you assume that the vessel is symmetrical about a longitudinal centreline, so you record only half the vessel. Imperfections are smoothed out in the final drawings which approximate to the builder’s original intentions. This is the quicker of the two methods and, if supplemented with the photographic survey, can provide an acceptable record of the vessel’s shape. It does however assume that there are no major distortions in the hull.
b. ‘longhand’ method – essentially the archaeological method of recording – where there are no assumptions about symmetry and no attempts are made to smooth out imperfections. Therefore any damage the vessel may have suffered, and any aberrations in the structure or general arrangements, will be reflected in the drawings. This will take significantly longer than the ‘shorthand’ method.

The ‘longhand’ method is of course preferable as this will provide a much greater level of detail but there may be practical reasons of time and budget for adopting the ‘shorthand’ approach. In some circumstances it may be pragmatic to combine both, for example taking the ‘shorthand’ approach to the overall shape (where this is not of paramount significance) and the ‘longhand’ approach to the layout of working spaces. However, the results should not be mixed in the same drawing, otherwise you may end up distorting your accurate ‘longhand’ drawings to fit your ‘shorthand’ spaces. Either way, all measured drawings should be accompanied by a statement on why you chose a particular methodology. This statement should also include the names of those who undertook the survey, the date, scales, legends for any symbols used, etc.

Almost all the vessels currently on the National Register of Historic Vessels were built using imperial measurements, and therefore, by surveying in feet and inches, structures and their relationships may be more readily understood. Despite this, few professional surveyors or surveying systems now use the imperial system and a decreasing number of people in this country understand it, so the metric system in some circumstances may be the best option. Where metric measurements are recorded, we strongly recommended that all dimensions are written in millimetres. Using centimetres together with millimetres is a recipe for confusion and using the metre as the base unit may result in misplaced decimal points.

Measuring the hull is the most complicated aspect of a survey and practically impossible if the vessel is in the water. It is sometimes possible to measure internally, but on many vessels internal structures prohibit access to the internal hull surface. Yet if the vessel is out of the water, even if she is not upright or on even ground, her hull shape can be captured.

5.1 Equipment

A vessel can be measured with very little equipment, such as:

- two steel measuring tapes, ideally as long as the vessel
- two smaller measuring tapes (at least as long as the vessel is wide)
- spirit level
- long transparent flexible PVC tube (ideally more than half the length of the vessel), 10 to 20 mm in diameter
- a small quantity (less than a litre) of clean water
- a straight edge, such as a length of planed timber, as long as the vessel is high
- two plumb bobs
- very large set square
- duct tape or similar
- box of map pins
- chalk
- notebook and pencil, ballpoint pen
- ball of string
- stepladder

This can of course be supplemented with laser measurers, laser levels, angle measurers, etc.

5.2 A method for recording a hull

The basic principle of hull recording is to create a virtual fixed horizontal and vertical grid around the vessel and ensure that all measurements taken can be related back to that grid.

Beware: it is surprisingly easy to take measurements 'in space' and discover later that these cannot be related to any other points you have located.

It is helpful if the vessel is upright longitudinally and vertically but not absolutely essential. But if the vessel is sitting on her keel, be aware that the keel may not have been designed to be parallel to her load waterline.

1. Securely fix a long tape to the ground alongside the side of the vessel – let us say the starboard side – parallel to the keel. It must extend between the extremities of the bow and the stern. Choose one edge of the tape to be your datum line.

2. Assuming that you are measuring from bow to stern, securely fix a shorter tape at 90º to the start of the datum line running in front of the bow. (This can be repeated at the stern, or this tape can be relocated after all bow measurements have been completed)

3. Securely fix the second long tape to the other side of the vessel, exactly parallel to the datum line so that the measurements align precisely. Your vessel is now effectively gridded. Record the distance between the two long tapes.

4. Drop a plumb bob from the centre of the extremity of the stem. Project a line at 90º from the datum line to the plumb bob and record the length of this line and its distance along the datum line. Repeat the process at the stern. This will establish the length of the vessel in relation to the ground.

5. On the starboard side of the vessel, mark a point on the sheerline with chalk or a map pin where the vessel appears to be at her widest.

6. Mark other points on the sheerline where the hull's shape begins to change. There should be at least five points (six including the widest point). Try to make these in places where it will be possible to measure the vessel's beam across the sheer. These will be the stations where the shape will be measured.

7. Drop a plumb bob from each of these points to the ground and, making sure that you are measuring at 90º to the datum line (using the set square or by triangulation):
   a) measure the distance from the plumb bob to the datum line
   b) measure the distance along the datum line to the line from the plumb bob.

8. Go to the port side of the vessel and using the measurements of distance along the datum line taken in Step 7b, locate the stations on the other sheer.

9. Climb on board and measure the beam of the vessel at all the marked stations. This must be the sheer-to-sheer external measurement. Do not make any adjustment for the vessel being at an angle: it hasn't yet been established if the vessel is upright either longitudinally or transversely. If there is superstructure or rigging which makes direct measurement of the beam impossible, find a way around this - perhaps by triangulating from other stations.

10. Returning to the starboard side, at each station, using chalk or map pins, draw a vertical line from the mark on the sheerline

down to the keel (one method of doing this is to suspend two plumb bobs from a timber extending over the side of the vessel at the station: keeping the string of both in line, the line can then be drawn by eye).

11. If you intend to measure both sides of the vessel, repeat Step 10 on the port side of the vessel in full, but otherwise draw the vertical line to a little below the lowest point of the port's sheer.

12. Fill the PVC tube with water, leaving around 200mm empty at both ends. Make sure there are no air bubbles.

13. Hold both ends of the tube. The water will self-level: mark this level with a pen on both ends.

14. Return to the midship station on the starboard side and carefully fix one end of the tube to the point on the sheerline, making sure that the water level is at the pen mark. It is essential that you check periodically that the water has not been spilt and the water level is still at the pen mark.

15. Taking the other end of the tube, place the straight edge vertically on the zero point on the datum line and, adjusting the tube so that the water level is exactly on the pen mark, measure and record the height of the water level to the ground. Repeat at the stern. Repeat at the start and end of the tape on the port side of the vessel. This will tell you whether the ground slopes or not and if so in which direction.

16. Take the tube to each station, again adjust it so that the water level is exactly on the pen mark, and make a chalk mark, or insert a pin at the water level. Repeat this at the bow and stern.

17. Take the tube to the port side and repeat. You now have a series of (albeit discontinuous) chalk marks on the hull which give you an accurately horizontal plane ('the waterline') to measure against. Put the tube aside.

18. Measure and record the vertical distance between the waterline and the sheer on all stations on both sides of the vessel.

19. On the vertical line drawn at each station mark six or more points that will convey the changing shape of the hull section. These points could be random, but preferably they should be at the bottom of strakes or plates as this would allow construction drawings to be created. Mark additional points at the top and bottom of the keel.

20. For each of these points, measure and record its vertical distance above or below the mark of the water level and its horizontal distance from the datum line. On even ground, this may be best achieved by triangulation - draw a line at 90º from the datum line to the bottom of the section; mark two points on this line as far apart as practical (bearing in mind that a tape has to reach each point on the hull section from these) and locate them in reference to the datum line; then record the distance from the two points to each point on the hull.

21. Mark a number of points on the stem. If the vessel is not upright, three dimensions must be recorded for each point – the vertical distance from the water level mark, the distance from the datum line and the distance along the datum line.

22. Relocate the tape to the stern and follow the same procedure as in Step 21 to capture the shape of the stern.

This procedure will record sufficient information to enable a basic measured drawing to be compiled. Further measurements and features can be added to create more and more detail, but always be mindful of how any measurement is related back to the datum line and the waterline. To fully record a vessel with sawn wooden frames will requite the measurement of each frame, and the angle of each face.

Archaeologists draw their surveys as they take the measurements, but this is rarely practical for working craft. However, because measuring a vessel relies on improvisation and ingenuity it is very difficult to set down measurements in an entirely systematic way. Ask yourself if your set of measurements will be understandable to someone in 20 years' time who may never have seen the vessel? We highly recommend that the measurements are converted into a drawing at the earliest opportunity.

5.3 Drawing up the measured survey

The size of the vessel will determine the scale of plans – conventional imperial scales are 1: 48 and 1: 96 and convenient metric scales are 1:50 and 1:100. At some time or another most plans will be copied and reproduced at different sizes which makes the original scale meaningless: a five-metre rule in scale should always be included on the plan.

Drawing a plan on paper (or preferably tracing film, which is difficult to tear or distort) requires not only a large drawing board but also specialist equipment such as a spline, spline weights and sets of ships curves, which are becoming increasingly expensive and difficult to find. Most plans are now drawn using 2D CAD packages. There are pros and cons to both: primarily the ease of the computer compared to the smoothness of a hand-drawn and inked line. For drawing on the computer, there are many software options. DELFTship has been created specifically for naval architecture for all sizes of vessel: a free version is available online. AutoCAD is the market leader among general CAD programs with LibreCAD as a free open-source alternative. However, any vector drawing programme could be used. 3D CAD packages, such as SketchUp, can be used but their starting point is a shape which is then manipulated, rather than a line, so they are more difficult to adapt for this purpose than 2D packages. It is of course possible to import 2D drawings into 3D packages if a 3D model is required at a later date.

There are a number of conventions in ships plans which should be followed, as they generally make it easier to develop a measured drawing into a plan: the profile view (the elevation) is drawn at the top left, with the plan view below. The vessel is drawn with the bow to the right. The body plan (the cross-section) is usually drawn to the right of the profile, so that lines can be extended.
Whether working on paper or on screen, the steps are the same:

1. Begin by establishing how level the grid was longitudinally and transversely. Draw a horizontal line (on the profile part of the drawing) to represent the 'waterline' level, roughly as long as the (scaled) length of the boat. Extend a vertical line from the bow to a point that represents the depth of the datum line below the water level at the datum line's 0 mark (A). Using the vessel's length as the radius, describe an arc from A towards the stern. Draw a horizontal line near the stern to represent the depth below the water level of the datum line at the stern. Mark where this line and the arc intersect (B). Draw a line between A and B. This represents the datum line, and reveals the angle at which the vessel sat.

2. Repeat the process to determine the relative height of the second long tape.

3. If the vessel was perfectly level longitudinally and transversely, it is possible to draw the stations together, following the body plan shown on page 48 – stations forward of midship to the left, stations aft to the right. If she was not level, each station must be individually drawn.

4. Mark the position of all the stations on the datum line, extending a vertical line up to the waterline on the profile view and down to where you will draw the plan view.

5. On the profile view, extend the horizonal line denoting the waterline to the right, to where you will draw the sections. Where the datum line intersects the midship station line extend another horizontal line. Locate all your measured points for this station on the vertical line and again extend a horizontal line from each one to the right.

6. To the right of the profile view, draw a vertical line through the horizontal lines you have just made. This represents the datum line, so on each line mark the location of each point's distance from the datum line. Join the points in a smooth curve.

7. Repeat Steps 5, 6 and 7 to draw the port station, or whatever part you have measured, using the distance between the two tapes to fix the location of the new vertical line from which you will locate the points. This will show clearly whether the vessel is on a slope.

8. Proceed to plot each point on the section, its distance vertical from the water level and its horizontal distance from the datum line. Join all the points in a smooth curve.

9. Repeat the process for each station.

10. Repeat the process for the bow and stern.

11. Return to the plan view and draw two horizontal lines through the station lines at a distance that represents the distance between the two long tapes.

12. Measure the distance on the section drawing from the starboard vertical line to the sheer at the midship station and transfer this to the station line on the plan view. Repeat this for all stations, on both sides of the vessel.

13. Draw a smooth line between the points to represent the sheerline.

The resulting drawing is the most accurate that can be produced from your data and should be preserved, along with your measurements.

5.4 Creating a lines plan from a measured hull drawing

If you wish to develop the drawing into a lines plan, where the actual shape of the vessel can be more readily understood, the process is relatively straightforward:

1. Redraw the cross sections, the bow and the stern so that the port

and starboard sheerlines, the bow and the stern are horizontal (although this may give some inaccuracy).

2. Copy the redrawn cross sections as half sections in the same style as a body plan (i.e. with the forward half sections to the left of a vertical centreline and the aft half-sections) around a vertical line representing the centreline of the vessel.

3. Grid the body plan with regularly spaced horizontal lines (a minimum of five) between the bottom of the keel and the maximum height of the bow (which will represent the waterlines) and vertical lines on both sides of the central vertical line to the edge of the vessel's widest point (representing the buttock lines). Diagonal lines can usefully be added as a cross-check of bilge shapes.

4. Begin a profile view by extending a horizontal line from the bottom of the keel.

5. Begin the plan view by drawing a horizontal line to represent the centreline of the vessel.

6. Locate the stations on this centreline using measurements from the measured drawing waterline, and extend vertical lines up to the profile drawing and down to the half-width of the vessel.

7. Plot the sheerline's height on the profile view and its half-width on the plan view.

8. Take the outer vertical line on the body plan and plot where it intersects each station on the profile plan. Join all the points to create a curved line – a 'buttock line'. Repeat with each vertical line.

9. Take the upper horizontal line on the body plan and plot where it intersects each station on the plan view. Join all the points to create a curved line – a waterline. Repeat with each horizontal line.

10. Erase everything on the body plan except the lines representing the bow and stern.

11. Erase the station lines on the profile plan and body plan and divide the vessel with 11 equally spaced vertical lines, and five equally spaced horizontal lines.

12. Re-draw the body plan by plotting the measurements from where the new horizontal lines meet the buttock lines on the profile view and the new vertical lines meet the waterlines on the plan view.

6. PHOTOGRAMMETRY

Photogrammetry works by software detecting ('registering') shared points in digital photographs and calculating the distance between them on x, y and z coordinates. The result is a point cloud that can be turned into a 3D mesh which defines the shape. It gives a realistic depiction of textures (which laser scanning alone cannot), it can be very inexpensive and undertaken by anyone who has a camera, the software and some patience to master the program. A mobile phone camera will suffice, although Digital SLR cameras generally produce a better result. There are several photogrammetry software packages available including Photomodeller and iWitnessPRO and Agrisoft although some of the cheaper ones do not allow measurements to be taken within the point cloud. There are free alternatives (such as Autodesk Remake and Regard 3D) but some do not directly import images and need an intermediary technology, such as VirtualSFM to create a point cloud.

Photogrammetry requires longer on site than laser scanning but it is not significantly less accurate: when the two techniques were compared by recording a 20,193-cubic-yard pile of gravel, photogrammetry produced an error of only 1.29 per cent against the laser scanned result.[6] Photogrammetry is widely used in the heritage community, particularly for smaller spaces and for individual objects. Photogrammetry's main drawback is that it requires texture on the images: it cannot cope with shiny or reflective surfaces, so it may therefore struggle with highly varnished woodwork and with brightwork. This can be overcome with a coating spray, but it is not something that can easily be used on large areas, and if not applied carefully can give a 'snowflake' effect on the resulting model.

A less serious issue is the number of images that are required. For photogrammetry to work there must be a substantial overlap where two images record the same feature. There must be at least an overlap of 60 per cent but the best models will be produced from images with an 80 per cent overlap or more. Feeding the resulting number of images into the software may be more than a standard home office computer can cope with. Do experiment before recording your vessel in earnest.

In order to gain the necessary images with the required overlap, the vessel must lend itself to this approach and be in a suitable location for the photographer to carry out a 360º walk-around. Smaller

[6] https://www.spar3d.com/news/software/will-photogrammetry-make-laser-scanning-obsolete/

vessels which are out of the water are ideal for this. Larger or more inaccessible craft may require the use of drones to assist in capturing them accurately.

As photogrammetry becomes a more popular technique it is possible to draw on the experience of others who have successfully used it to record craft. In some cases, volunteers have been trained to take the images and have then worked with a consultant to input them into a software program. A number of free or subsidised workshops have also been held in recent years to inform vessel custodians of the advantages of this approach and demonstrate how to apply it. In addition to providing a clear record of the vessel, it can be used to allow people to 'walk around' the interior in virtual form and therefore has considerable value as a tool for public access. For example, Historic England captured data of the *Rooswijk* wreck on the seabed by this means, thereby providing a mechanism for people to explore the remains in a virtual tour and removing the exclusivity of access which was previously only available to those able to dive on the site.[7]

See Appendix E for an example of photogrammetry applied to a historic vessel.

7 https://www.cloudtour.tv/Rooswijk

7. LASER SCANNING

Laser scanning, also known as HDS (high definition scanning) or lidar ('light detection and ranging'), is currently the most accurate method available for measuring a vessel. There are three systems: triangulation (the most common), pulse and phase-comparison, but they effectively all deliver the same thing: the x, y and z co-ordinates of millions of points on a surface. This is manifested in a graphic image known as a point cloud. Although this is simply a collection of dots, surfaces are clearly distinguishable.

To scan an entire vessel, scanners can be moved to several locations and the sets of overlapping data can be combined, a process known as 'cloud-to cloud registration'. This is usually done by fixing targets on a surface that is located in both scans, but some scanners are capable of recognising common surfaces between different data sets and combining them automatically.

The results can be combined with photographs, either taken by the scanner or an external camera to add colour and differentiate surfaces more clearly. As well as resulting in a 3D model of the vessel, software applications can convert the data into conventional 2D plans.

Laser scanning is quick, it records everything visible, doesn't require any special lighting (or indeed any lighting at all), can be undertaken by one person, does not involve touching the vessel and (if it is a Class 1 or 2 scanner) will not injure the eyesight of either the operator or anyone passing. It offers huge potential for interpretation – particularly the possibility of virtual reality walkthroughs of a vessel. The method has only a few minor technical shortcomings:

- it does not detect edges clearly
- transparent or reflective surfaces cannot be scanned well
- registering interior with exterior scans is not always straightforward
- scanning does not differentiate between materials
- the point cloud files are huge and not all computers will be able to handle this amount of data.

There is also one major disadvantage: the expense. Laser scanners can cost over £10,000 to which has to be added the software and training. Both scanners and software can be hired, but this too is expensive: online quotes at the time of writing are more than £2,000 for the scanner for two days. On top of that, the software is not intuitive and some training will almost certainly be needed before useable results can be obtained.

Laser scanning has been around for several decades but does not seem to have become less expensive, and there are no signs that it will do. A simpler system may be developed in time, but at the moment there are no indications of this happening soon. Therefore, for the foreseeable future, laser scanning will remain principally in the domain of professional surveyors.

If you are able to commission such a professional survey, check whether the software your surveyor uses has a free viewer for interrogating the outputs.

See Appendix F for examples of laser scanning.

8. PRESERVING YOUR RECORDS

8.1 Paper

Records kept on paper still have a number of significant advantages over digital ones. They are not reliant on technology, or the continuation of software support, and if appropriate inks, and good photographic paper are used, and stored in dark, dry, fireproof conditions, they do not readily degrade.

If you are printing documents, always use acid-free archival paper: this is widely available. Standard paper is likely to have a high acidity content, thanks to the manufacturing process. For long-term preservation, paper must be kept out of daylight as much as possible, at a temperature around 20^{o} C and in a place where the relative humidity is around 55%. If the humidity is too high (above 65% for a couple of days or more), mould is a possibility; if the humidity is too low then paper can become dry and brittle.

Pollution, insects and animal infestations can also seriously damage paper documents, so precautions must be taken:

1. Remove all rubber bands (which will deteriorate and may leave a permanent stain), paperclips, staples and pins from the documents (which may eventually leave rust stains). If paperclips are absolutely necessary to keep a sub-set of papers together, use a stainless-steel, brass or plastic-coated paperclip but with a strip of acid-free paper between the clip and the documents.
2. If documents are frequently used, photocopy them and avoid using the originals, or keep them in polyester sleeves and don't allow them to be removed from these.
3. Don't repair a torn document with adhesive tape: carefully place it into a polyester sleeve and don't remove it.
4. Store documents in acid-free folders, and keep them flat. Keep groups of documents in acid-free boxes.
5. Secure boxes and folders (if necessary) with unbleached cotton tape.
6. Keep boxes and folders in fireproof cabinets and chests.

Newspapers are often very brittle because of the wood pulp content in the paper. Place them between acid free boards and secure them. Newspaper clippings are equally vulnerable – the best answer may be to photocopy onto acid-free paper, keeping one as a reserve.

Plans should ideally be kept flat but if there is no alternative, they should be rolled around an acid-free cardboard tube and then enveloped with acid-free tissue or paper.

8.2 Photographic images

Printed images should be stored in sleeves made from polyester and polypropylene film or in neutral pH photographic storage paper. As with all paper, relative humidity and temperature should be kept low, but it is particularly important that the levels don't fluctuate, or the gelatine image may crack.

Unlike paper documents, it is better to store prints on their edge rather than flat, especially if they are mounted, as deformation of the backing can lead to uneven support and delamination or cracking can result.

Albums should be kept in acid-free cardboard boxes so that they are protected from light and dust.

If you want to store prints in an album, don't use the self-adhesive type, as the acid paper and the adhesive may stain the print as well as make it impossible to remove the print after a period.

Glass negatives and slides should also be stored upright, ideally in custom-made lidded boxes where each negative or slide is housed in an individual folder of polyester film.

PVC (poly vinyl chloride) plastic folders should not be used for any long-term storage and particularly not for black and white prints and negatives because, as the plastic deteriorates, it gives off vapours that will tarnish the images.

8.3 Non-digital films

Cine-film and videos are almost obsolete now and it will become increasingly difficult to find machines to play them. Have these transferred to a digital format as soon as practical. In the meantime:

- make sure that films are wound evenly round the spool and store films in snugly fitting rust-free canisters in a cool, dark and dust free environment.
- store cassette tapes upright in a dust free atmosphere away from strong light and temperature and humidity fluctuations.
- make sure that a rewound tape is not under tension.
- keep films away from any source of a magnetic field, such as

electric motors, TV sets, photocopiers, or the tapes could be wiped.
- run tapes through to the end so that popular sections are not worn unevenly.

8.4 Storage of CDs and DVDs

Like cassettes, CDs and DVDs are becoming obsolete, so ensure that the contents are copied and treated like any other digital document or image. In the meantime, store them vertically in the boxes in which they came and avoid putting labels on the surface of the disk. Don't leave disks in a drive.

8.5 Audio files

MP3 (formerly MPEG – Moving Pictures Experts Group – 3) is the most common audio format and is supported by almost all devices. It is however a 'lossy' format, like JPG: to reduce the file size, data is compressed using approximations and discarding parts of it. Recordings in MP3 will not be noticeably of a lower quality, but the loss of quality will be evident if they are converted to another lossy format. It is preferable to record in a lossless format such as the open format FLAC (Free Lossless Audio Codec) or WAV (Waveform). There is no difference in sound quality between these two formats but FLAC has inbuilt compression so the files are about half the size of WAV files.

8.6 Digital documents

Most digital documents are created by desktop packages such as Microsoft Word, Excel and PowerPoint. Unfortunately, software versions keep changing and after a few years are no longer supported. For long-term preservation, and to prevent them being accidentally overwritten, they should be converted to Portable Document Format (PDF), which is usually an option within these packages. However, if the format of the document is important there may be a problem with preserving it. If you open the PDF on a computer which does not have the fonts installed with which the original was written, the computer will make a best guess, which could turn the format of the document into something slightly scrambled. Microsoft Word, for example, currently has a font called Calibri as its default – this is not a font that is installed on a Mac.

On a Windows version of Microsoft Word, there is a menu item 'Save As', and a drop-down menu will give "PDF" as an option. A sub-menu "Options" will appear: make sure the 'ISO 19005-1 compliant (PDF/A)' is checked. This is not possible with Microsoft Word on a Mac without purchasing Adobe Acrobat (version 8 or above), but the free LibreOffice Writer offers PDA/A as an export option.
If a word-processed document is purely text and the formatting is not essential, Rich Text format (that is, a file with the suffix '.rtf') could be used, although Microsoft users could stick with Word's 'doc' format. Again, there is usually an option to save as a Word document in other word processing package. Spreadsheets could be saved as in CSV format (Common Separated Values – .csv). However, both these formats leave the files vulnerable to being overwritten, so PDF/A is a safer format.

If documents are scanned, they should be as PDF or TIFF (Tagged Information File Format) at 150 dpi (dots per inch) for text, 300 dpi for images.

Drawing files should ideally be scanned as both a PDF and in a graphic image format such as DWG ('drawing').

8.7 Digital image formats

As noted above, most cameras have JPG (or the older JPEG – Joint Photographic Experts Group) as the default file format. Unfortunately, every time a JPG is saved, renamed or moved it re-compresses itself, losing something of the original quality. JPG images must be copied as quickly as possible, the originals preserved and the copies used for viewing.

JPEG2000 by contrast does not have the compression problem and is a format of choice in North America by institutions such as the Library of Congress and the Google Library Project, which suggests a secure method for the foreseeable future. However, it has not caught on in the UK, where TIFF has become a common format for images, as well as scanned documents.

With new photography, the preferred format is RAW (or Raw – it is not an acronym), which captures far more detail than any other format. The drawback is that RAW images cannot be viewed without being converted, and each camera manufacturer seems to have their own proprietary software for conversion. Any of these could disappear at any time. Therefore, the preference is to convert RAW files to DNG (Digital Negative) files. Many of the larger cameras have an option to save photographs in DNG.

All digital records should be reviewed every five years to ensure that they are still readable and steps undertaken to convert them if formats are likely to change before the next review. Back-up records should be held in alternative formats and stored separately in appropriate conditions.

8.8 Keeping records

Paper and film records should be kept in fire-proof cabinets.
For digital records, the recommendations above are not necessarily for the best formats, but they are the ones expected to be supported for the greatest length of time. However, problems with digital media are likely to come not from the software but from the hardware. Machines are not designed to work indefinitely. Although there are firms who can recover data from hard and external drives, it is not always possible. Memory sticks are particularly vulnerable to corruption, as well as to being lost. It is essential that three copies of digital records are kept, on different machines and in different locations. We suggest a server, a home computer and the Cloud (on Dropbox or similar). You should also speak to your local museum or archive and see if they are willing to store your data.

Records should be held in perpetuity and wherever possible in such a way that they can be made available to researchers and other vessel owners. There may come a time when the recorded vessel can no longer be kept or is so degraded that what remains does not reflect what was once there. The records then become the only source of information. If records are kept in private ownership, or by associations, NHS-UK asks that a list of the information that comprises your summary of the vessel, indicating where the data is stored, is lodged with us for reference. We also urge holders of records to identify a repository which can take the records in the event that a time comes when they themselves are no longer able to do so. We can advise on appropriate bodies to approach as NHS-UK itself has limited storage facilities and it is not possible to hold all data for every craft on the National Registers. More detailed information is kept for those vessels in the National Historic Fleet and owners looking for a suitable repository to hold their vessel record should consult us about what is practical for NHS-UK to take or whether a more suitable repository exists elsewhere.

8.9 The National Archive of Historic Vessels

When a vessel that is on the National Register of Historic Vessels reaches the end of its life, its register entry is transferred to the National Archive of Historic Vessels, which is also managed by NHS-UK. This database contains details of over 500 vessels previously on the National Register of Historic Vessels which have now been broken up, lost, sunk, or whose owners have been out of contact for a considerable period. When a vessel is archived, staff will review the vessel record or summary provided by its owner, as well as all details held on file, to ensure that an accurate and updated overview is given in the entry and links are provided to sources elsewhere. The vessel images accompanying the entry may include those generated as a result of recording through photogrammetry or laser scanning. Any report on a vessel's deconstruction will also be uploaded along with her statement of significance. The National Archive of Historic Vessels is, in many cases, the last accessible record of a craft that no longer survives and it provides a valuable tool for researchers, historians, enthusiasts and those looking to build a replica.

9. FURTHER GUIDANCE

This document provides the essential information for recording vessels but further guidance on specific issues can be obtained from the sources given below.

Recording oral history	Professional advice and support are offered by the Oral History Society, c/o Department of History, Royal Holloway, University of London, Egham Hill, Egham, TW20 0EX
Laser scanning	Historic England publishes guidance on-line which is periodically updated. It is free and available from: https://historicengland.org.uk/images-books/publications/3d-laser-scanning-heritage/
Photogrammetry	Historic England also publishes guidance online on photogrammetry: https://historicengland.org.uk/images-books/publications/photogrammetric-applications-for-cultural-heritage/heag066-photogrammetric-applications-cultural-heritage/
Recording by measured survey	Richard Anderson's *Guidelines for Recording Historic Ships* is the most extensive publication on how to record, although the method varies slightly from that described here. It is available online at: https://www.nps.gov/hdp/standards/HAER/GRHS.pdf
Care of records	Basic preservation guidelines are issued by the National Preservation Office (http://www.bl.uk/services/npo/pdf/basic.pdf), Guidelines for the Care of Records is produced by the British Records Association: (http://www.britishrecordsassociation.org.uk/publication_pages/Guidelines1.htm). Also of relevance is the Arts & Humanities Data Service, Digital Archives from Excavations and Fieldwork: guide to good practice, London, 2000.

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Appendix A: Risk assessment for recording vessels

The following is a generic risk assessment template for visiting historic vessels, included here for reference only. Circumstances in which vessels are recorded vary enormously, and those undertaking this work must take all precautions to ensure their safety and those of others. NHS-UK bears no liability for any omissions or the interpretation of this template.

	SEVERITY
1	First aid injury
2	Minor injury
3	3-day recovery
4	Major injury
5	Disability / Fatality

	LIKELIHOOD
1	Very unlikely
2	Unlikely
3	Likely
4	Very likely
5	Almost certain

SEVERITY

LIKELIHOOD	1	2	3	4	5
1	1	2	3	4	5
2	2	4	6	8	10
3	3	6	9	12	15
4	4	8	12	16	20
5	5	10	15	20	25

Low risk Medium risk High risk

Standard hazards

	Likelihood	Severity	Risk (L x S)
Falling in the water			
Weil's Disease			
Head injury from low deck heads or rigging			
Transport from base to location of vessel			
Falling whilst boarding vessels/scaling ladders/rigging			
Slip/trip/fall whilst on vessel			
Tetanus from rusty fittings			
Electrocution			
Asbestosis			
Other (specify)			

Pre-survey precautions

1. Brief all team members about the objectives

2. Ensure that all team members understand that the survey is at their own risk

3. Have a realistic plan of what can be achieved in the time available (especially the available daylight)

4. Identify the location of toilets, washing and places to eat on site

5. Check the weather forecast

6. If the vessel is near or on water, establish whether all team members are competent swimmers

7. Ensure all phones are fully charged

8. Give each team member a card to state they may have been exposed to Weil's disease

On-site precautions

1. Inform someone on site (such as a security guard) of your arrival and your anticipated time of departure

2. Keep an eye on all team members

3. Wear suitable protective clothing – with extra protection for the knees and with high visibility markers

4. Wear slip resistant shoes

5. If on or near water wear life jackets of at least 50 Newtons, serviced every two years.

6. Have a first aid kit in easy reach of the team

Appendix B: Oral history recording agreement template

[INTERVIEWER'S NAME AND ADDRESS]

Interviews with people associated with [VESSEL NAME] are being recorded and preserved as a permanent reference resource for use in research, publication, education, lectures, broadcasting and the internet. The purpose of this Agreement is to ensure that your contribution is added to the vessel record with your consent and in accordance with your wishes.
This Agreement is made between [THE INTERVIEWER] and [THE INTERVIEWEE]:
Interviewee's name:..
Interviewee's address:.. in regard to the recorded interview/s which took place on:
Date:..
Declaration: I, the Interviewee confirm that I consented to take part in the recording and hereby assign to the interviewer all copyright in my contribution for use in all and any media. I understand that this will not affect my moral right to be identified as the 'performer' in accordance with the Copyright, Design and Patents Act 1988.

If you do not wish to assign your copyright to the Interviewer, or you wish to limit public access to your contribution for a period of years, please state these conditions here:
....
....
This Agreement will be governed by and construed in accordance with English law and the jurisdiction of the English courts. Both parties shall, by signing below, indicate acceptance of the Agreement.

By the **Interviewee**:

Signed:...

Name in block capitals: ....

Date: ....

By the **Interviewer**

Signed: ....

Name in block capitals:...

Date: ....

Appendix C: NHS-UK criteria and scoring system

To be included on the National Register of Historic Vessels (NRHV) a vessel must meet the following criteria:

Be at least 50 years old
A minimum of 50 years must have elapsed since the vessel's keel was laid or her build was begun
Have demonstrable and significant UK associations
At least one of the following statements must be true about the vessel:

- she was built in the UK
- she was built abroad but built for specific purpose related to the UK
- she is connected to the UK by a specific significant event or person
- she spent at least 50% of her working life in UK waters.

Be based in UK waters
The vessel must be currently in the coastal and internal waters of the United Kingdom as recognised by international maritime law, including those of Northern Ireland, the Isle of Man and the Channel Islands, but excluding those in the Republic of Ireland and the British overseas territories. Static vessels based ashore within the United Kingdom (as defined above) are also eligible for registration.
Be more than 33ft in length overall (33ft 1 in. (10.6 metres) or above)
We define a vessel's length overall as the measurement between the forward and aft extremities of the hull overall excluding any spars or projections.
Vessels below 33 feet in length overall can apply for registration on the National Small Boat Register.
Be substantially intact
If more than 70% of the hull structure is intact the vessel can be considered for registration. Any vessel which is less intact than this will only be considered for registration if national significance can be demonstrated to the satisfaction of NHS-UK.

In order to assess vessels for inclusion on the National Historic Fleet, NHS-UK uses a scoring system as a means of initial evaluation. The table below sets out a series of core scores against which a vessel can be assessed. This methodology was published as part of a public consultation on the National Historic Fleet Review in 2014 and may be subject to change. Further specialist scores may also be added in relation to groups of vessels with unique characteristics.

		SCORE	0	1	2	3	4	5
1	*All vessels*	**Age**	Less than 50 years old	50 – 99 years old	100-149 years old	150 – 199 years old	200-249 years old	250+ years old
2	*All vessels*	**Innovations (new ideas and techniques**	Contains no design innovation of importance / unknown builder and designer	Contains one important design innovation (plus 1point for known builder or designer)	Contains two or more important design innovations (plus 1point for known builder or designer)	Add one point for each named innovation (maximum 4 points) plus an additional point for known builder or designer.		
3	*All vessels*	**Historical associations (people, events and operational area)**	No historical associations	Solely local significance	Solely regional significance	Regional significance with elements of national significance	National significance with elements of international significance (e.g. at least one rescue involving international shipping	Clear international significance (e.g. took part in Dunkirk evacuation)
4a	*Vessels whose primary purpose is static preservation (afloat or ashore)*	**Level of originality (hull fabric / design features / vessel form / rig/ internal and deck fittings)**	No conservation principles applied / very little original fabric or features surviving	Vessel preserved / restored with introduction of considerable new materials	Vessel preserved / restored with substantial original fabric or features missing	Vessel preserved / restored with some loss of originality to all elements	Vessel preserved / restored with hull significantly intact but with some features missing or over restored	Vessel preserved with exceptional originality of fabric and key features of form and function intact
5a		**Condition**	Significant problems, fabric in extremely poor condition, or state unknown	Fabric in poor condition and declining	Unsatisfactory, fabric being inappropriately preserved or unstable	Visible improvement in condition of vessel stabilised, but with limited controls in place	Satisfactory, with any minor changes under control and monitored	Optimal - vessel stabilised and regularly monitored in appropriate environmental conditions
4b	*Vessels whose primary purpose is operational use*	**Level of originality (hull fabric / design features / vessel form / rig/ internal and deck fittings)**	No conservation principles applied / little original material surviving	Significant reconstruction, adaptation or maintenance work which doesn't use like-for-like materials or changes vessel's appearance	Extreme reconstruction applied using conservation principles	Major reconstruction . Adaptation resulting in loss of key features or new material out-weighing old	Reconstruction or adaptation where key features have been accurately and sympathetically replicated using like-for-like materials without impact on form or function	All key features of form and function intact: no reconstructive work carried out other than maintenance / minor reconstruction or restoration work resulting in minimal introduction of new materials
5b		**Condition**	Very poor and deteriorating condition or state unknown	Significant localised problems	Vessel in need of repairs / significant re-fit / no maintenance policy	Vessel in good or stabilised condition / regular maintenance	Condition very good / any localised problems do not prevent operation / annual maintenance plan in place	Condition excellent and 5 year + maintenance plan in place
6	*All vessels*	**Rarity (based on number of other known vessels)**	100 plus	51-100 surviving examples	11 - 51 surviving examples	6 - 10 surviving examples	2 -5 surviving examples	Unique survivor

Appendix D: Case studies of manual recording

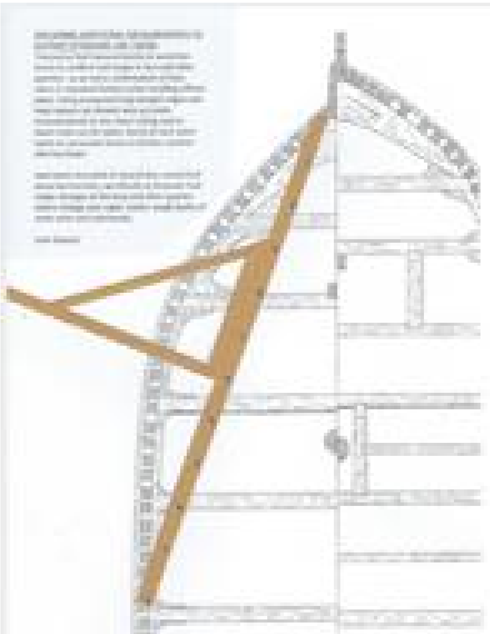
Measuring the stern of *Jhelum* (John Kearon)

Jhelum

Jhelum was a wooden barque built in Liverpool by Joseph Steel and Son and launched on 24th May 1849. As a general cargo vessel, she carried a range of cargoes around the world but in 1870 in Port Stanley she was declared unseaworthy and abandoned. She was, as Mike Stammers and John Kearon described her, 'a ship that deserves to be famous for being ordinary' – neither fast nor glamorous, she was a representative of the thousands of vessels that were the uncelebrated workhorses of international trade. The last surviving Liverpool wooden barque, she was one of more than a dozen hulks – which at one time included ss *Great Britain* – that lay around Stanley Harbour.

Investigating the depth of the hull (John Kearon)

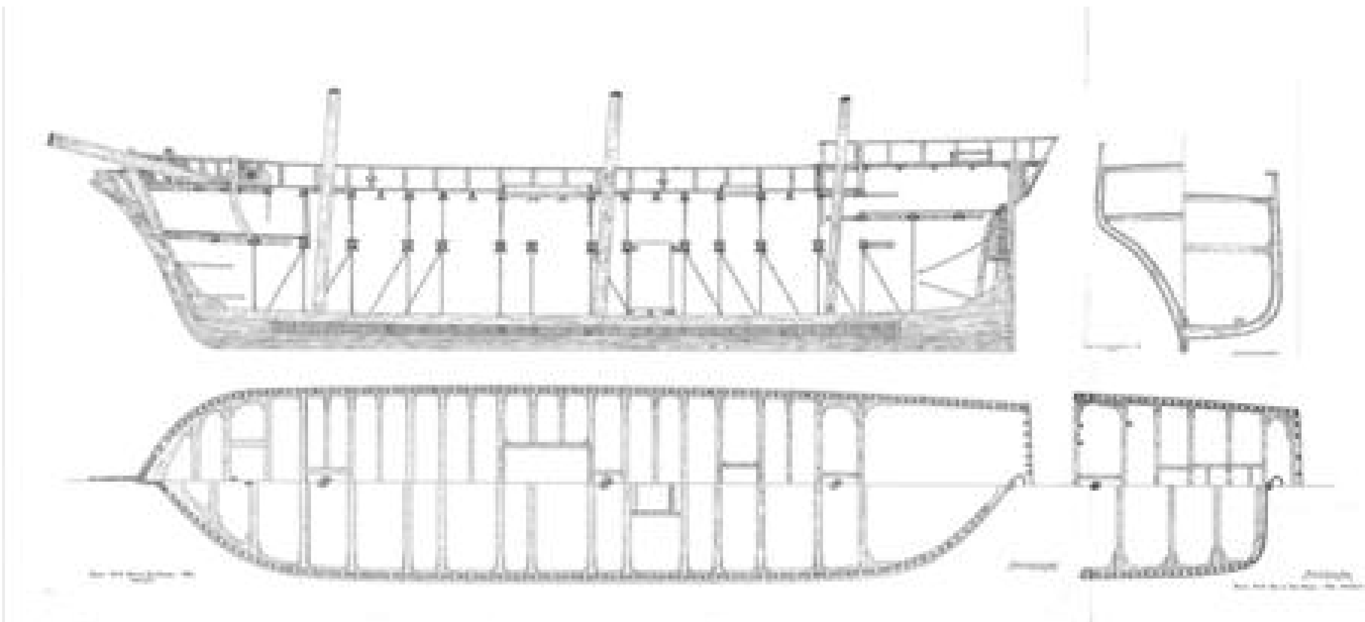
Mike, then Keeper of Merseyside Maritime Museum and John, at the



time Head of Shipkeeping Conservation Department, undertook three field trips to the Falklands between 1987 and 1990, to record *Jhelum* and other significant vessels, as well as to advise on the establishment of the Falkland Island Museum. In the recording of *Jhelum*, John undertook to take her lines while Mike concentrated on measuring components and fittings.

She lay on her port side at an angle of around 45º, a short distance offshore in a tidal zone and, because of this, the difficulties of accurately measuring the exposed starboard side and the vagaries of the weather which limited recording time, the measuring was mainly undertaken inside the ship. All the measurements were to the starboard side of the hulk.

Measuring was made more difficult by the distortion of the hull over its length and the forward bow section leaning further to port than the after section as well as a possible hog in the keel. It was not helped by the bottom being submerged (even at low water the top of the keelson was four feet under). In these circumstances setting up a fore and aft centreline and measuring from it would not have produced accurate lines. However, such a line was set up from the centre of the apron to the centre of the sternpost which meant that by measuring from the line to both keelson and centres of beams, both transverse and longitudinal distortion could be checked.



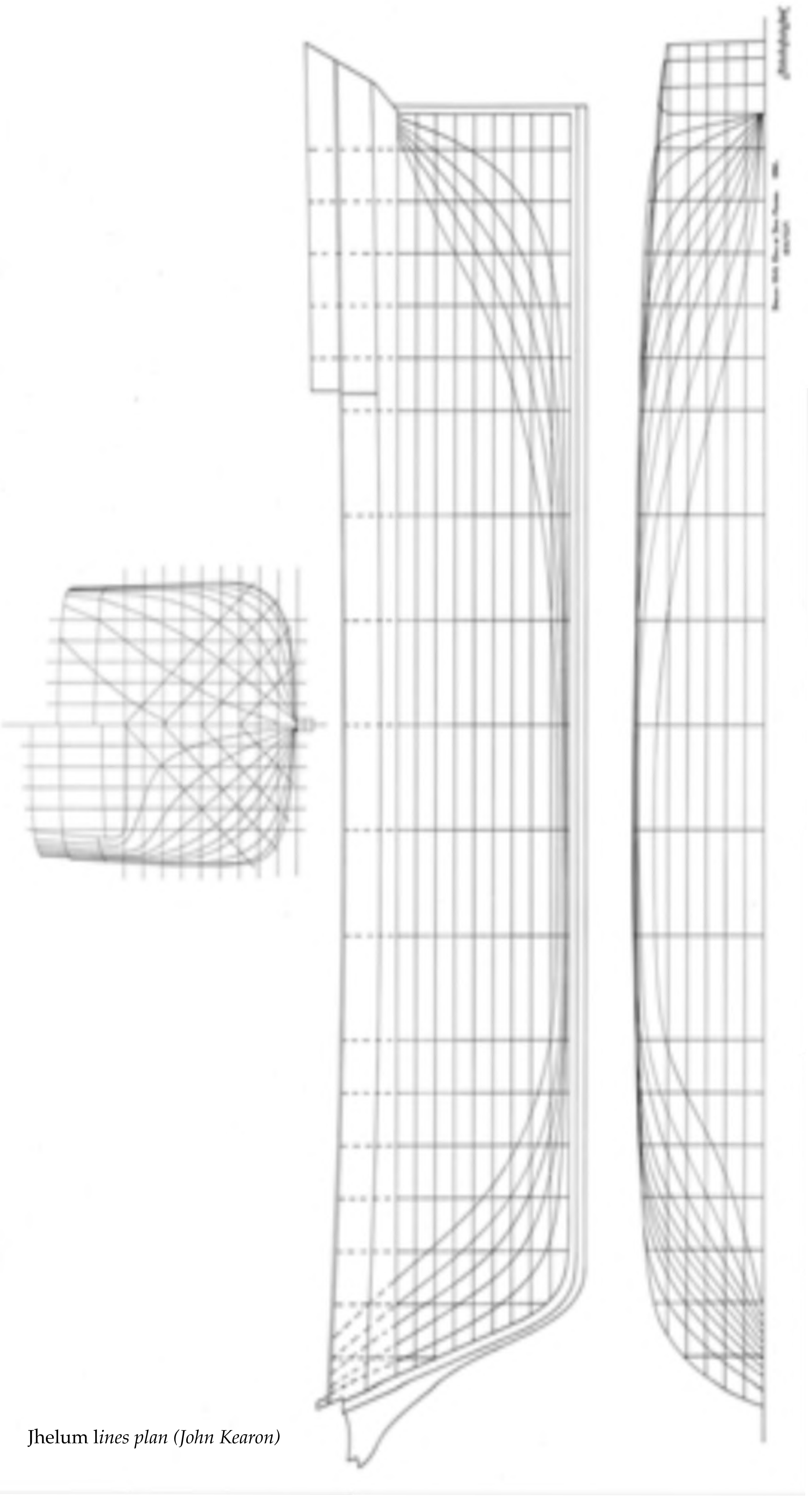
Jhelum *structural plan*
(John Kearon)

At ten stations along the ship, a wooden straight-edge was fixed vertically between the centre of a main deck beam and a hold beam. This straight-edge was marked with lines two feet apart (which would become waterlines on the resulting drawing), and one of the lines was fixed at the level of the underside of the hold beam. A large wooden T-square was then aligned with each waterline and a long batten slid along its upper edge until it touched *Jhelum*'s side and the distance measured. The same method was used with a large 45° set square, producing diagonal measurements.
In the few locations where it was possible, a measured steel bar was rammed through the rubble in the bottom to the ceiling at 2-. 4- and 6-foot distances from the centreline. Measurements were then taken from the bar to a waterline.

A further set of measurements was taken forward and aft where the shape altered rapidly. Here a straight edge about 30 feet in length and marked at two-foot intervals, was set up horizontally from the centre of the sternpost to a point where a deck-beam met the side. Using the T square, a series of measurements was taken from the straight-edge to the inside surface of the ship at each two-foot interval. The process was repeated both forward and aft.
All the main structural features and their individual components -- the bow, stern together with the frames, deck beams, knees, shelves, and waterways, planking and ceiling, chainplates, the windlass, main hatch and skylight were all recorded, as were rigging fittings. Marks were often vital clues, for example of the layout of the officers' cabins in the poop.

Some features however, remained undiscovered, such as the dimensions of the keelson, deadwoods, forefoot and exactly how they were fitted together. Her sheer was calculated using a combination of the known depth of hold amidships, the draught marks forward and aft and measurements taken to the top of the stem and stern posts from the ship's draught marks. It was difficult but eventually resolved by a dive which revealed a false keel of 11 inches and the realisation that an early survey which indicated she had no sheer was incorrect – it was in fact a rise of one foot forward and nine inches aft. Sadly, her bow collapsed during a storm in 2008 and the stern followed suit in 2013, so she is now considered a complete loss, but our knowledge of her survives thanks to the work of Mike and John.

A full account of the ship's history and her recording is published in Michael Stammers and John Kearon, *The Jhelum: a Victorian merchant ship*, Sutton Publishing 1992.



Jhelum l*ines plan (John Kearon)*

Emily Barratt: measuring cross-sections

Emily Barratt *with measuring vertical and horizontal in position (John Kearon)*

Emily Barratt was the last vessel built by the Duddon Shipbuilding Company (and the last schooner built in England). Ordered by the Hodbarrow Mining Co. in 1910, she was launched on Easter Monday, 1913. She traded for the iron company until 1922, was then sold and continued to trade until 1960, interrupted in the War by a spell as an anchorage for a barrage balloon. Unfortunately, her condition deteriorated beyond the point where she could be conserved and she was broken-up at the Dock Museum, Barrow in 1999. However, before she was lost she was measured by John Kearon.

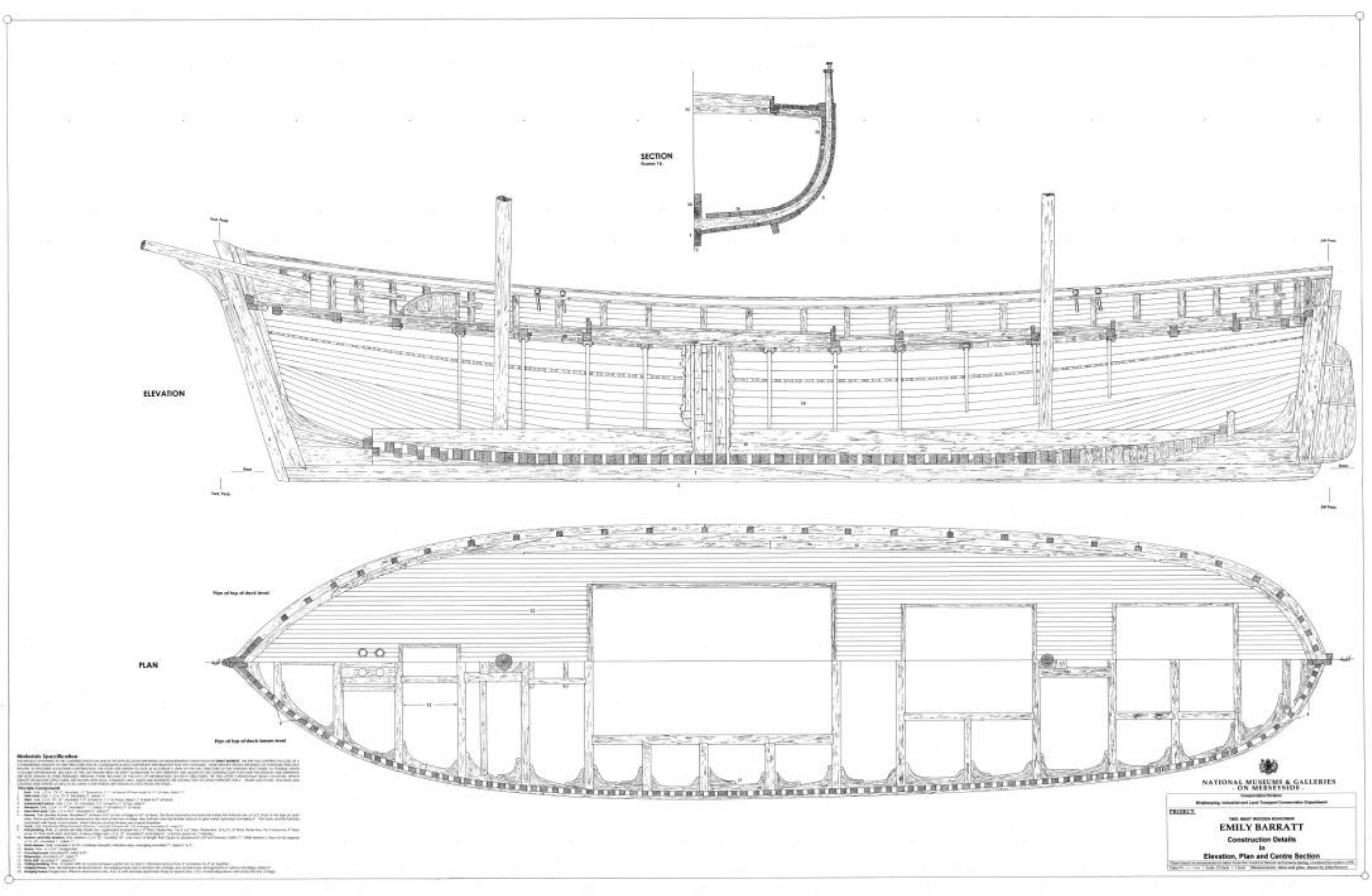
At the time of recording she was out of the water, resting on keel blocks on hard level ground and supported with props. By checking the angles of stem and stern posts she was found to be perfectly upright. Fortunately, despite some damage, there were no signs of hull distortion, probably due to her very strong double-frame construction, the substantial hull planking and being completely planked inboard.

This gave John confidence that it would only be necessary to measure one half of the vessel, as she was symmetrical, and he decided take measurements off the outer port side of the hull, where there was almost completely free access to the entire hull and keel. Seventeen stations along the schooner's length were identified, each located at the after side of a deck-beam. The beams confirmed the original width of the vessel at each location.

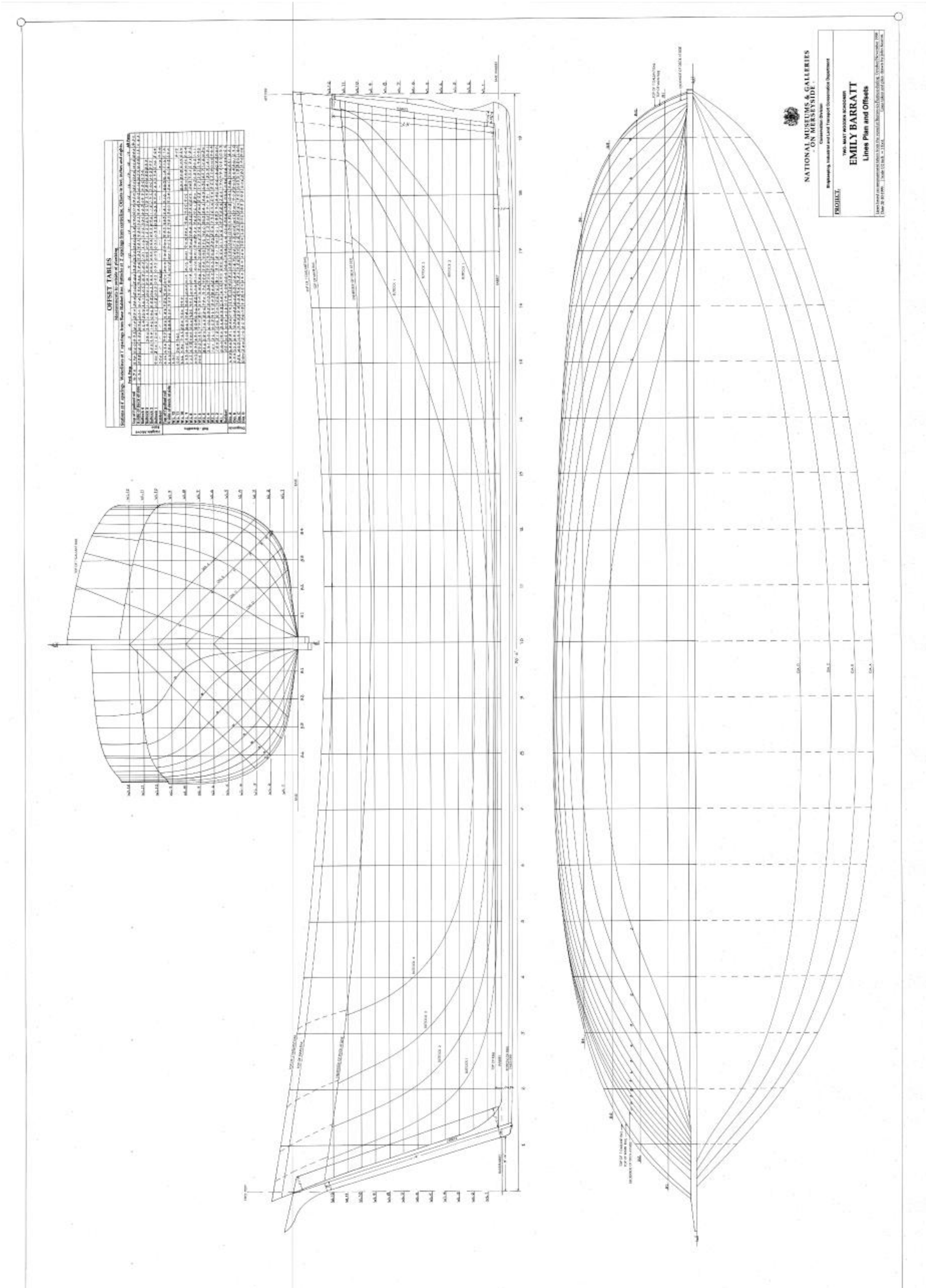
A bespoke frame was created to capture the cross-sectional shape of the hull at each of the 17 stations. It consisted of a straight-edge (a plank) as long as the schooner was high and placed vertically at the station. Twelve evenly spaced marks from which the waterlines would be drawn, were made on this straight-edge, the lowest aligning with the bottom of the keel. To this plank, another straight-edge was clamped horizontally. This was marked with nine regularly spaced marks, from which the buttock lines would be drawn. Horizontal and vertical distances from the waterlines and buttock lines respectively to the hull were then measured, using a long spirit level and a third (smaller) straight-edge.

In addition, a large protractor was set up at the junction of the vertical and horizontal straight-edges, with angles of 60, 45 and 30 degrees marked. By measuring the distance from the hull to the junction the turn of the bilge could be captured accurately.
It took John three full days to measure the *Emily Barratt*, largely working alone.

The measurements taken were processed and drawn using traditional naval architecture tools (splines, ducks and ships curves) at a scale of two inches to the foot (1: 6), to provide a complete set of offsets to produce the lines plan, first in pencil and then in ink on draughting film. Spread over three months, drawing up took around 60 hours.



(John Kearon)


OFFSET TABLES
NATIONAL MUSEUMS & GALLERIES
· ON MERSEYSIDE ·
EMILY BARRATT
Lines Plan and Offsets

(John Kearon)

Appendix E: Photogrammetry case study

Mary Anne *on the cradle, with her waterlines and buttock lines superimposed (Stuart Norton)*

Mary Anne is the last surviving rowed ferry used on Lake Windermere. Her date of build is uncertain – she may have been constructed as early as 1799 – but she was still in service as a ferry as late as 1870. She was recovered in 1978 and forms part of the collection at Windermere Jetty.

After decades spent on the lake followed by constant exposure to the weather, *Mary Anne* was in a fragile condition and collapsing under her own weight. She was so out of shape that there were only two stations (the transom and close to the bow) that could be used to take the lines using traditional lofting techniques. A method of recording was needed that could capture the details of fabric and shape before any interventions were made and for this reason, photogrammetry was chosen and Stuart Norton, a CAD specialist, commissioned to undertake the work.

Since photogrammetry requires matching similar points in multiple photos in order to derive the three-dimensional position in space,

The cradle design (Stuart Norton)

Mary Anne was prepared with high-contrast marker points that could be seen easily. Red-and-white tape was used to roughly section the hull, as this provides high-contrast precise marker points. Fifty photographs were loaded into the photogrammetry software, Photomodeler, and the chosen marker locations were input on every photo, in order for the software to calculate the positions in three dimensions of each of the markers. Manually linking corresponding points on 50 of the photographs was a time-consuming process and took around two weeks.

The software needs to be told scale, so the vessel's existing rectangular cradle provided a good means of inputting the scale in two axes. Other reference measurements were also input in order to verify the level of accuracy.

The scaled 3D marker positions were then exported into hull-modelling software, Delftship, in order to provide a guide to recreate an estimate of the hull shape. Given the collapsed state of the vessel, historic photos of *Mary Anne* were key in helping iterate towards the hull-shape. The hull was exported into CAD software called Rhino, which allowed the hull to be overlaid onto a handful of historic photos, which gave clues as to whether the shape was correct. Any modifications were performed in Delftship, and the process repeated until a level of confidence was reached. In all, this process took around three weeks.

Using the estimated hull shape, a set of supports for *Mary Anne* were made and installed on the cradle. Having these installed gave the opportunity to re-scan her and repeat the process. The second time photogrammetry software called Agisoft Metashape was used, which doesn't require manual marking. The resulting scan was compared in Rhino with the hull-model in order to tweak the hull before re-making some of her supports. The accurate 3D record made it straightforward to design and create these supports – they were used to push back and hold the collapsing hull in her original shape. Installation was done while the wood was still wet allowing some pliability without breakage.

The cradle is steel 'I' and 'C' section beams welded together. Fixed to the steel are wide wooden wedges (100mm wide) at six stations along the hull. These wedges were accurately cut using a CNC (Computer Numerical Control) router driven by code taken from the 3D CAD model. The wedges are extended in places to support the collapsing freeboard, port and starboard. Wedges are lined with museum-grade plastazote to cushion the hull.

The boat is now awaiting further conservation, but is stabilised and exhibited under a building overhang, out of the weather.
Free photogrammetry software is now available, such as Meshroom, which will enable the 3D construction of objects from a good set of

photos. However, Stuart recommends that for archiving purposes, once a set of photos with a scale reference is shown to produce a valid 3d model, it would only be necessary to store the photos since photogrammetry software and file formats will change over the coming decades.

The rendered 3D model of Mary Anne (*Stuart Norton)*

Appendix F: Case studies of laser scanning

The *Antxustegi* is a wooden tuna-fishing vessel, built in 1958 and one of the few surviving examples of a type of ship that evolved from the Basque steam fishing fleet. After her working life she was donated to the Bilbao Maritime Museum where she was dry docked.

One of the stations for hull recording: the image created can be seen on the screen (J.M. Matés Luque)

When her condition threatened her survival, a decision was made to ensure that she was properly recorded. Laser scanning was selected as the preferred method because of its relative speed, efficiency and unmatched accuracy. It was also the safest method for the recording – the condition of the hold made it unsafe for detailed measurement to be undertaken by hand. There was also an awareness that the technique had been successfully applied on other historic vessels, including the clipper *City of Adelaide* and HMS *Victory*.

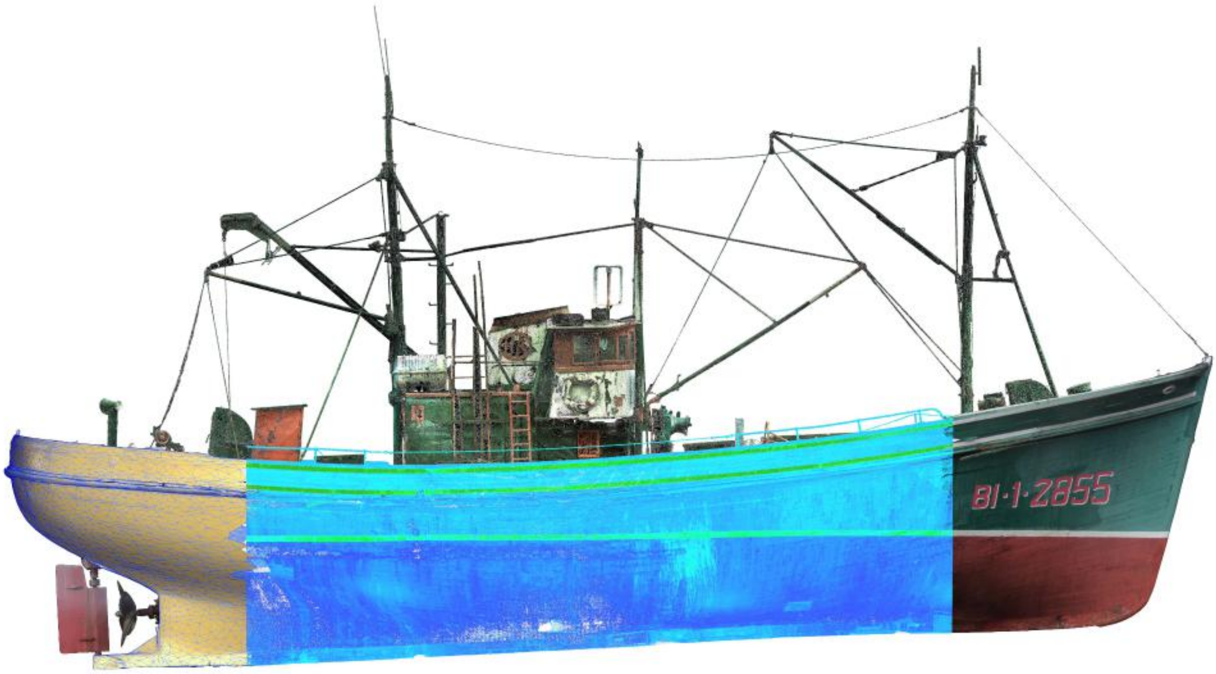
José Manuel Matés Luque (a freelance archaeologist) and Oskar Moral Goirigolzarri (a professional surveyor) were commissioned to undertake the scanning. The process began by placing numerous bull's eye targets in, on and around the vessel, to act as reference points for overlapping scans. In addition to recording X, Y and Z co-ordinates of scanned points, the scanner also recorded the intensity of the laser beam bouncing back (i). Not only that, the scanner – a Leica Scanstaion c10 with an accuracy of 2 mm – included a calibrated camera which recorded the red, green and blue (R,G,B) values of the colour at each point.

Once the scanner was set up at a station it took an average of 20 minutes to scan an area, and in total three days (or 18 work hours) were needed for two people to complete the scanning at twenty-four stations. Because of its condition, scanning in the hold was somewhat limited, and it was safe to scan at only two positions. Similarly, the

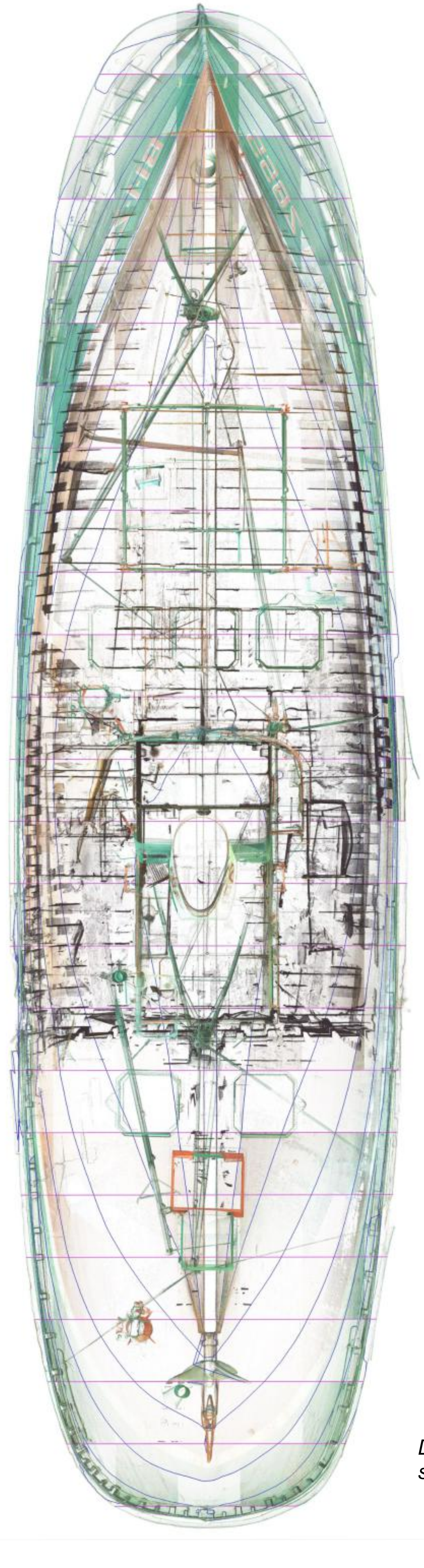
upper deck was unsafe in places and again it was only possible to scan at two positions. The remainder of the stations were either in the dry dock or on the pavement at the edge of the dry dock.
Post-scanning processing was undertaken with Leica Cyclone software to create a point cloud. Using 3DReshaper a triangular mesh was generated over which sections, photographs, etc. could be laid. Points which added nothing – such as those relating to the dock wall – were removed to clean up the model and reduce the file size. The mesh could then be outputted in a number of formats including a lines plan, a two-dimensional model and a 3D video, all of which were included in the final report.

Luque and Oskar saw one of the principal benefits of the scanning as establishing a baseline for the *Antxustegi* which regular monitoring would check against for any loss, alterations or damage. They are strong advocates of this recording method, particularly because of its speed and non-intrusiveness. Their ambition is to set up a digital register of Basque timber vessels. At the time the recording was undertaken, the *Antxustegi* was under threat of loss. However, she has subsequently been conserved (and the laser scan played an important role in this process.

(A fuller account of the scanning can be found in José Manuel Matés Luque and Oskar Moral Goirigolzarri, '3D Laser Scanning of a Mid-20th Century Basque Fishing Vessel: the *Antxustegi*, a model for the digital recording of the Basque traditional fleet', in J. Letwin (ed.) *Baltic and Beyond: change and continuity in shipbuilding*, ISBSA 14, Gdańsk 2017.)



The 3D mesh, the colourless point cloud and the coloured 3D mesh combined (Oskar Moral Goirigolzarri)



Development of the lines plan from the laser scan (Oskar Moral Goirigolzarri)

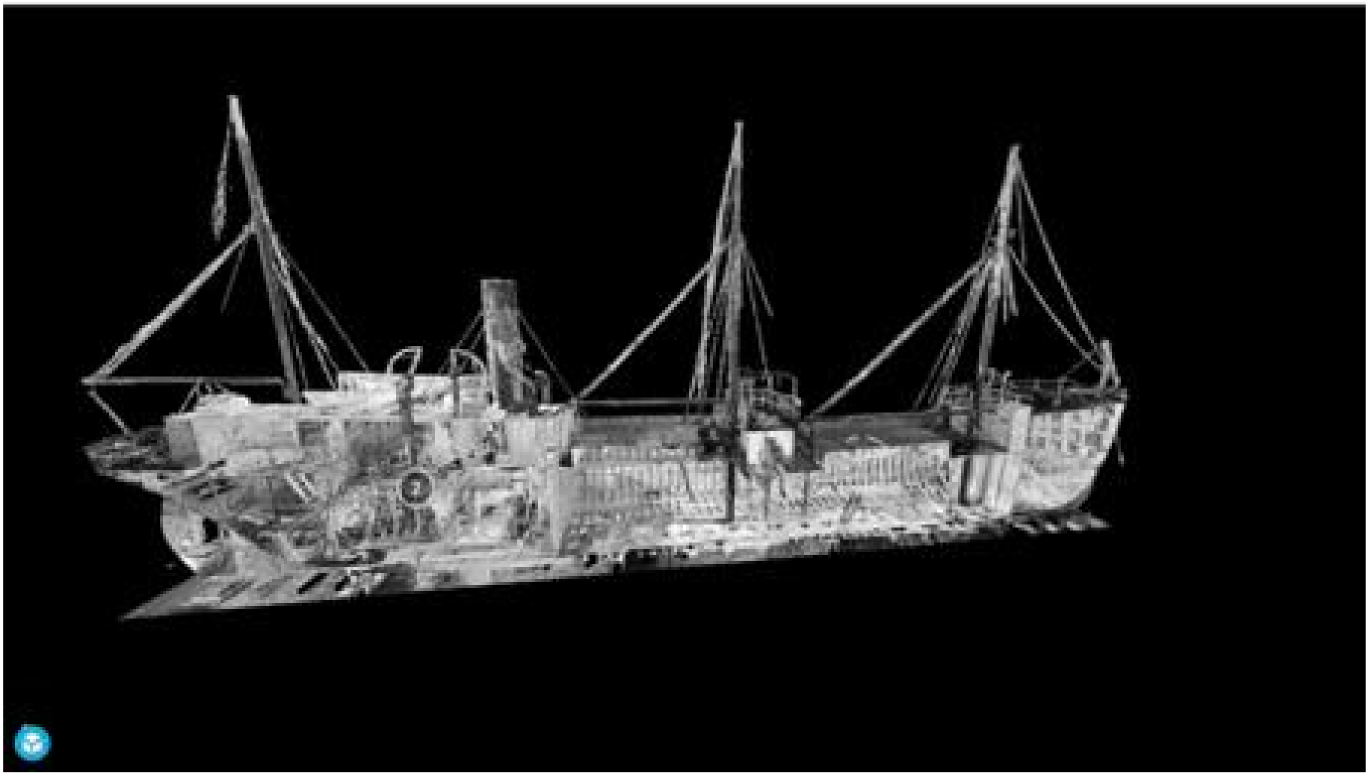
3D modelling of historic vessels on the web

Several historic vessels have uploaded 3D models to the web, including:

The Scottish Maritime Museum, which has models of *Carola*, *Spartan* and *Kyles* as well as a model of the Scotch boiler from the paddle steamer *Waverley*.

https://sketchfab.com/ScottishMaritimeMuseum/models

The coaster SS *Robin* has uploaded a point-cloud model.



http://ssrobin.com/3d-gallery.

A video of the scanning and rendering process for RSS *Discovery* has been uploaded by Digital Surveys.

https://www.youtube.com/watch?v=0mFk-T9BPF8

The Downland Partnership has uploaded a video of the laser scan of HMS *Victory*.

https://www.youtube.com/watch?time_continue=7&v=QGXBtHDydJQ&feature=emb_logo