J. Richard Steffy Ship Reconstruction Laboratory

ShipLAB

TEXAS A&M UNIVERSITY

# Recording Early Modern Hull Remains

Report 35

Draft 1 - April 2018

CMAC

Center for Maritime Archaeology & Conservation

Filipe Castro, Charles Bendig, Marijo Bérubé, Ricardo Borrero, Nick Budsberg, Chris Dostal, Miguel Martins, Rodrigo Torres, Kotaro Yamafune

**Foreword**

This little report is intended for young nautical archaeologists and follows a number of other reports and presentations made by the ShipLAB team for the UNITWIN network.

We strongly believe that archaeologists should adopt a common methodology to record ship's hull remains, so that they can be easily compared and shared among the growing community of nautical archaeologists.

It is available online at https://tamu.academia.edu/FilipeCastro/UNITWIN, together with a glossary in six languages, and we expect to improve the graphics and the contents of these collective projects.

# Basic proceedings for recording and publishing shipwreck hull remains

## 1. Introduction

We have an impressively small sample of ship remains from the period than spans from the Bronze Age to the Renaissance.

As J. Richard Steffy put it, some were built to transport goods across bodies of water, some were built to fish, some for commerce, and some for war. They were a part of everyday life of the societies that built and operated them, sometimes inconspicuous and sometimes admirable. They were a product of the culture, the territory, and the ecological conditions that determined their shape, structure and construction sequence. They were imbued with meaning and existed in an ideological frame.

None of these important factors can be grasped, however, if we don't understand how they were conceived and built, how their shape was controlled, how they were repaired and controlled, and what building materials were used, or why they were chosen.

The first step to study the history and significance of ships and boats is to excavate, record, and publish their hull remains in a clear and concise way, and to make available for reinterpretation the primary data that allowed their concise and clear publication (Castro et al. 2017).

Publications should always contain a location map, a short description, plans, sections, and images, and a scantlings list.

Below we propose a standard approach to shipwreck publication. It is understood that the level of detail in a report depends on the money, time, site conditions, and means available to the team.

This report is indicative and proposes a standard structure for the publication of shipwrecks, and follows the steps adopted by J. Richard Steffy in the 1970s. We believe that, having been around for half a century, the present structure has endured the methodological and technological changes of two generations of nautical archaeologists and stands as a solid frame for the description of a shipwreck.

And we hope that more archaeologists adopt this standard, so that comparative studies become easier and quicker, as data sharing and peer review of surveys and excavations.

We hope that sharing primary data becomes the norm in our research field, and that the younger generations of nautical archaeologists will use the internet to share their primary data and replace the 19$^{th}$ century paradigm, which preferred the publication of final reports after decades of secret studies, to the hard sciences way, in which knowledge increases constantly by small increments.

## 2. Description of the site

The first step in describing a shipwreck is an introduction containing:

1. The location of the site, including the depth, elements preserved, and the probable site formation process;
2. A short history of the site, detailing how it was found, whether there is indication that it was salvaged or looted since the shipwreck, and dates and bibliography pertaining to its surveys and previous interventions;
3. A description of the remains: rough dimension of the ballast pile, number and size of anchors, number and size of guns, the nature of the cargo, personal artifacts, the rough dimension of the hull remains, and description of its main components;
4. A short description of the most relevant artifacts apparent;
5. A location map;
6. A site map of the site as found on the seabed;
7. Cross-sections of the site in orthogonal directions;
8. A tentative identification of the site with a description of the most probable chronological range (*terminus post quem* and *terminus ante quem*);
9. An account of the basic construction features apparent, specifically related to known architectural signatures.
10. A first impression of the wood characteristics (e.g. hard or soft), tree ring-width average, conversion technique (e.g. tangential cut, split) and growth pattern (e.g. knots, grain flow orientation, roots or canopy).

**Example of a location map:**

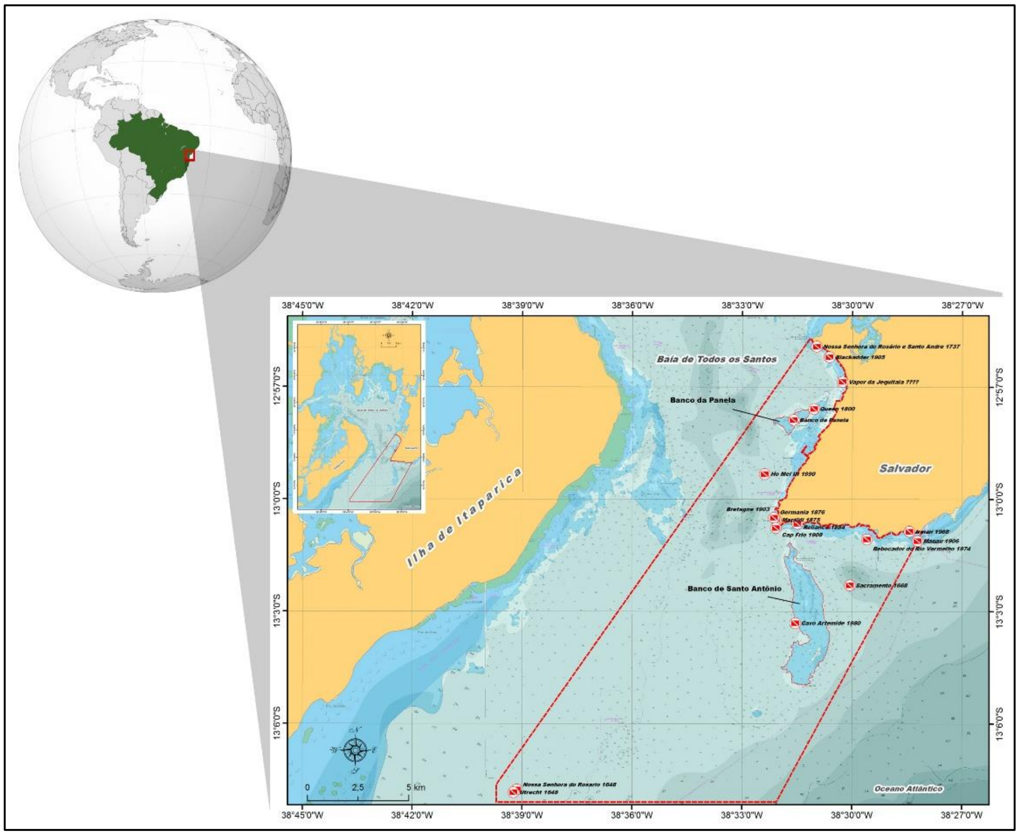



Figure 1 – Location map of the Project Observabaía (Torres 2016).

The recording of a site must tell the story of the archaeological intervention. It is normal and common for archaeologists to make mistakes, and a continued recording can mitigate or even resolve this problem. The first step of every intervention is the definition of a sufficient number of fixed datum points. Sites should be recorded before any cleaning or intrusive action is taken.

Once the basic site plan is developed and scaled – if there is enough visibility photogrammetry is the cheapest, quickest, and most precise way to record a pre-disturbed site as a mesh or a point cloud – cleaning and tagging all apparent elements is the second step.

Unless the structural remains are completely exposed and can be clearly interpreted, it is good practice to number all hull components sequentially, as the timbers are exposed or recorded, regardless of their function or position.

If photogrammetry is a viable option, periodical tridimensional meshes of the surfaces exposed can be saved, published in real time on the internet, and compounded later, as the earliest ones will have better detail of the surfaces exposed (timber surfaces erode quickly during the excavation).

Ideally ships should be disassembled and each timber recorded in detail. This practice is expensive and time consuming, and it is often impossible to do more than to select a small number of diagnostic components, and record them in detail.

**Examples of site maps:**

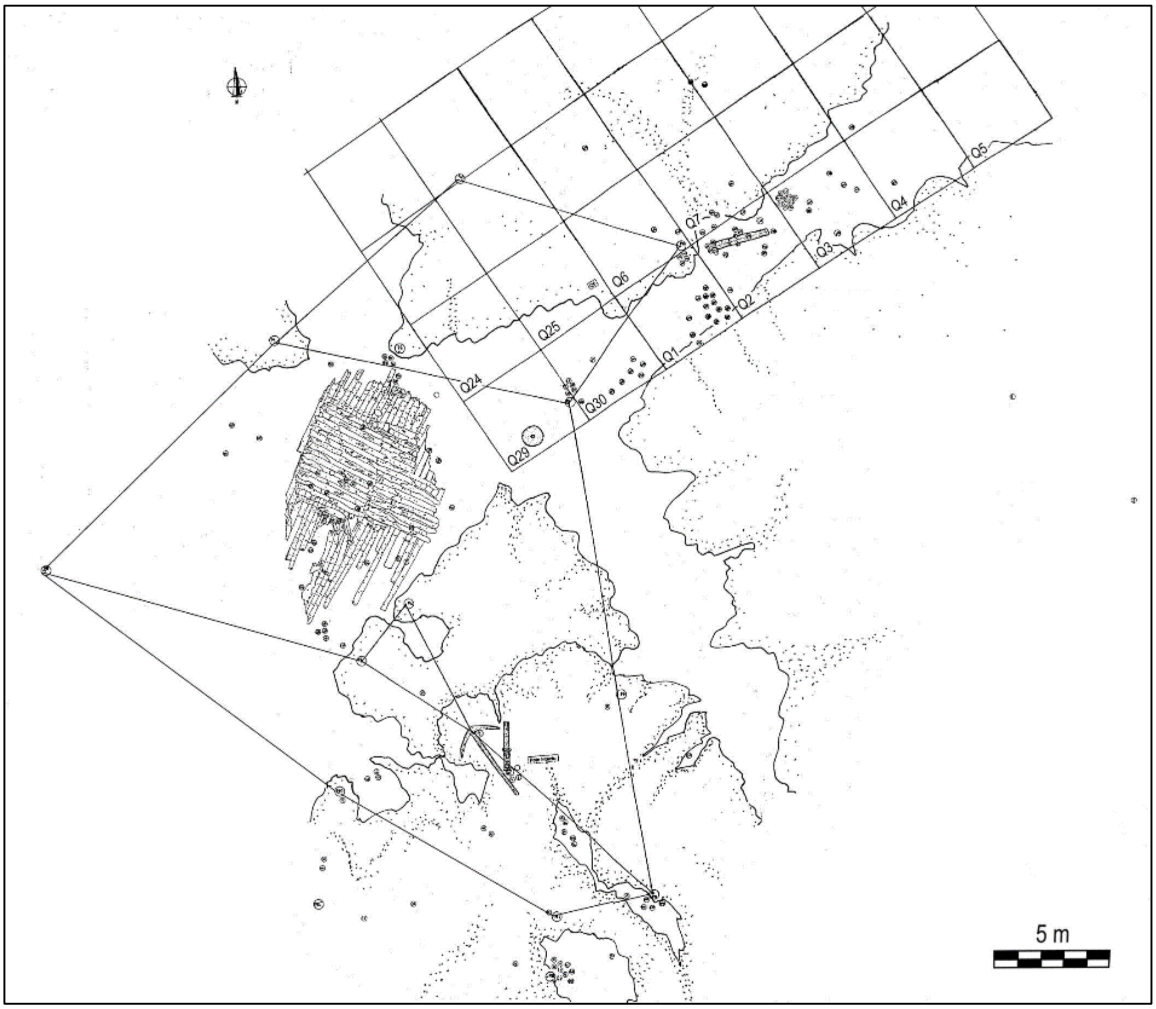



Figure 2 – Pepper Wreck (Castro 2003).

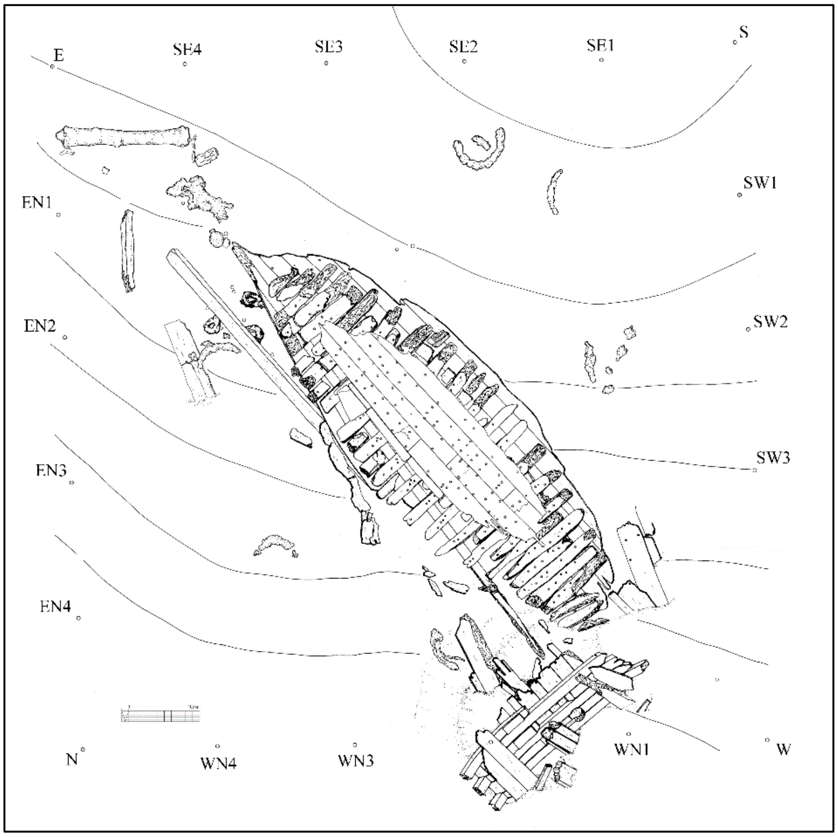


Figure 3 – Arade 1 (Castro 2005).

The characterization of a site should include:

1) The size of the hull remains preserved;
2) The estimated reconstructed size of the ship (keel length, length overall, beam, depth in hold, etc.);
3) A tentative characterization of the ship, including the number of decks, masts, rigging type, function, etc.;
4) A short description of the timbers preserved, preferably presented in a table with two columns, indicating the designation and description of the hull components preserved;
5) A summary table with the list of the most important scantlings;

Once a site is described and the hull remains characterized, it is paramount to describe each timber analyzed.

Mapping a site requires some training and can be facilitated by the use of computers. Trigonometry programs such as *Site Recorder 4* can produce good maps from direct measurements between datum points and particular points in the structure to be mapped. If there is enough visibility, computer vision can make the tasks of mapping a site extremely easy (Drap and Long 2001; Drap et al. 2003; Drap et al. 2013; Drap et al. 2015; Yamafune et al. 2017).

Using the principals of photogrammetry, computer vision can produce point clouds or meshes with the shape and color of the surface recorded down to centimetric precision. These clouds can be sliced to produce sections and combined to reveal the changes occurred during the excavation process.

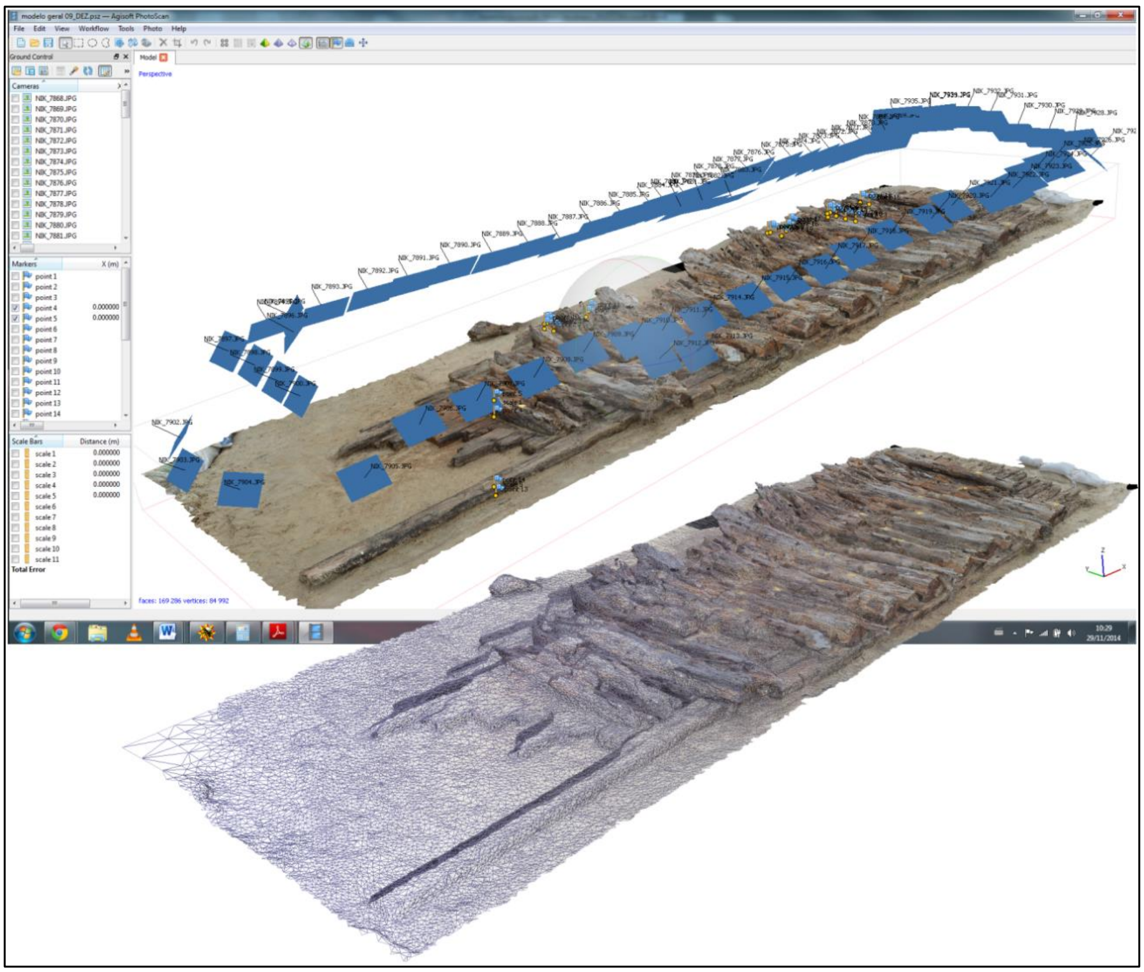


Figure 4 – Lagoa do Peixe site (Torres 2015).

Meshes can also be used to produce scaled orthophotos, which can be worked in GIS to produce layered maps with different construction features (Torres 2015).

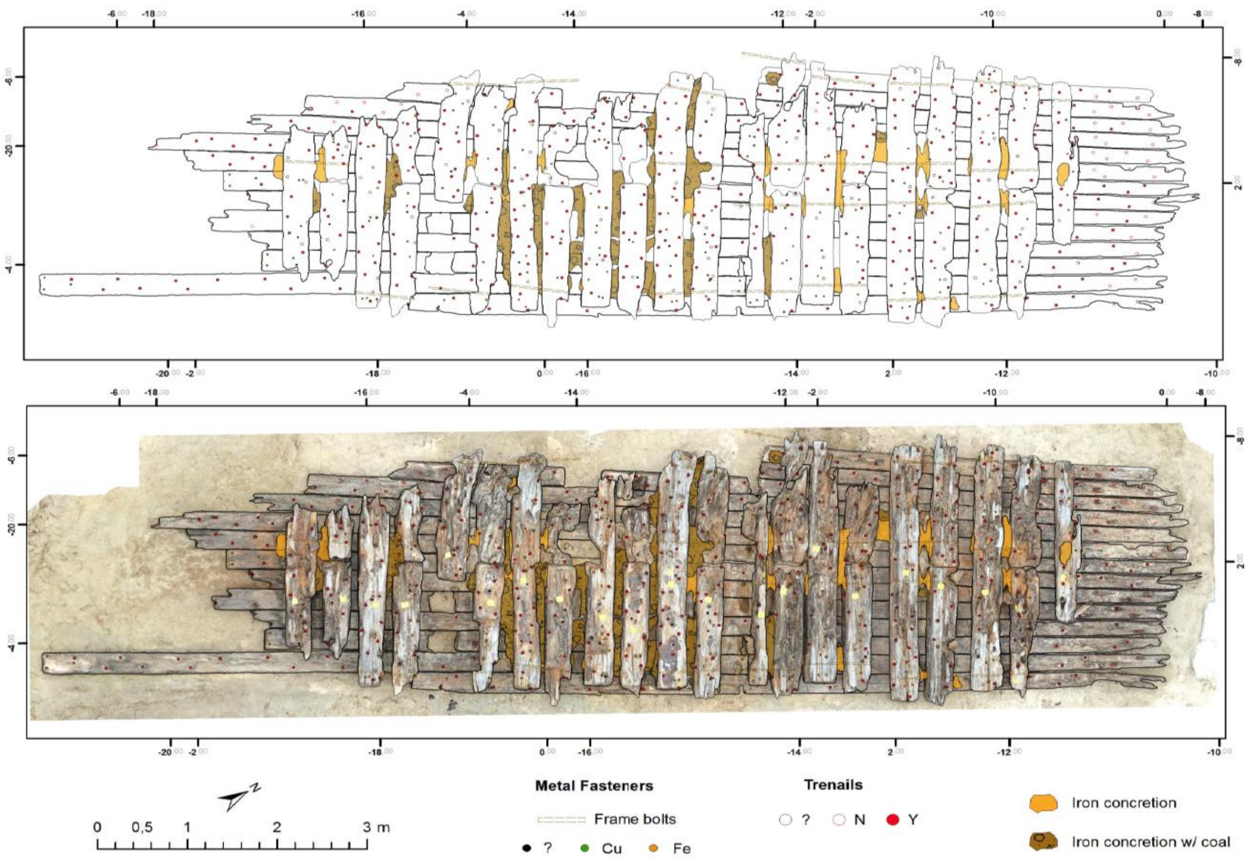



Figure 5 – Lagoa do Peixe site scaled orthophoto (Torres 2015).

## 3. Timber Catalogue

The second section in a shipwreck hull report should be a catalogue of the timbers preserved, which should be organized in the following way:

1. A scaled site plan with the upper layer of timbers tagged, which generally should include:
    a. Keelson and maststep;
    b. Aprons and filling timbers at the bow;
    c. Deadwood and filling timbers at the stern;
    d. Stringers and breast hooks;
    e. Ceiling planking;
    f. Pumps and pump sumps.

2. A scaled site plan of the keel and framing structure with all floor timbers and futtocks tagged;

3. A scaled plan of the lower layer of the hull structure with all timbers tagged, which should include:
    a. Keel and posts;
    b. Hull planking;
    c. Wales.

4. A table with each timber referred by its tag number, and characterized by the following measurements:
    a. Additional location information, e.g. square, layer, or depth (if necessary).
    b. Length preserved;
    c. Length reconstructed (when possible);
    d. Sided dimension;
    e. Molded dimension;

## ***Examples of site plans with two and three structural layers preserved:***

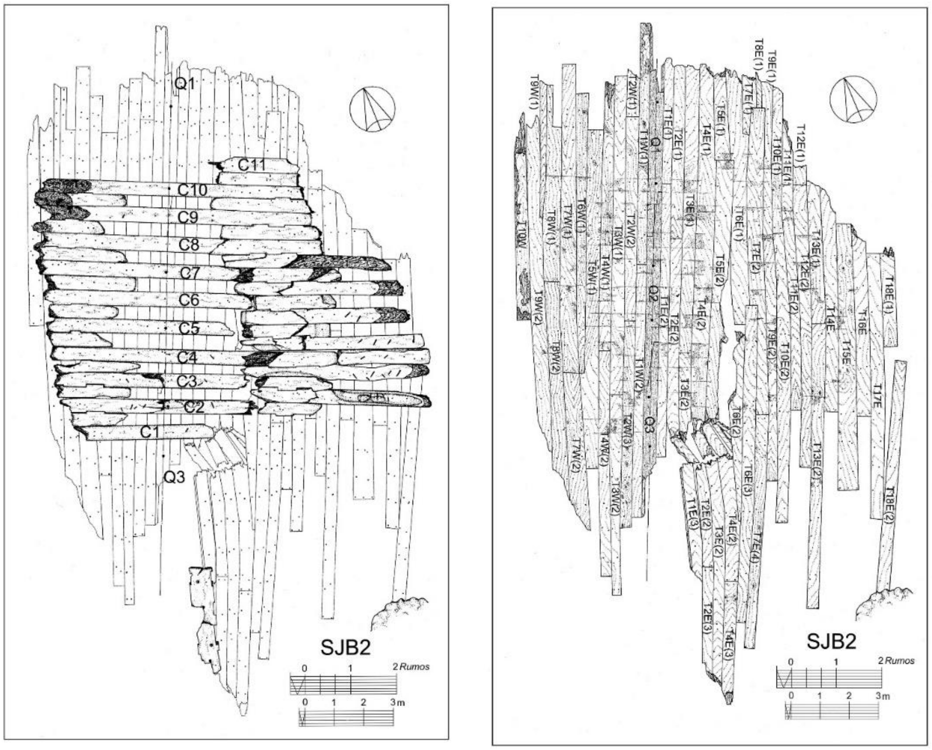



Figure 6 – Pepper Wreck (Castro 2003).

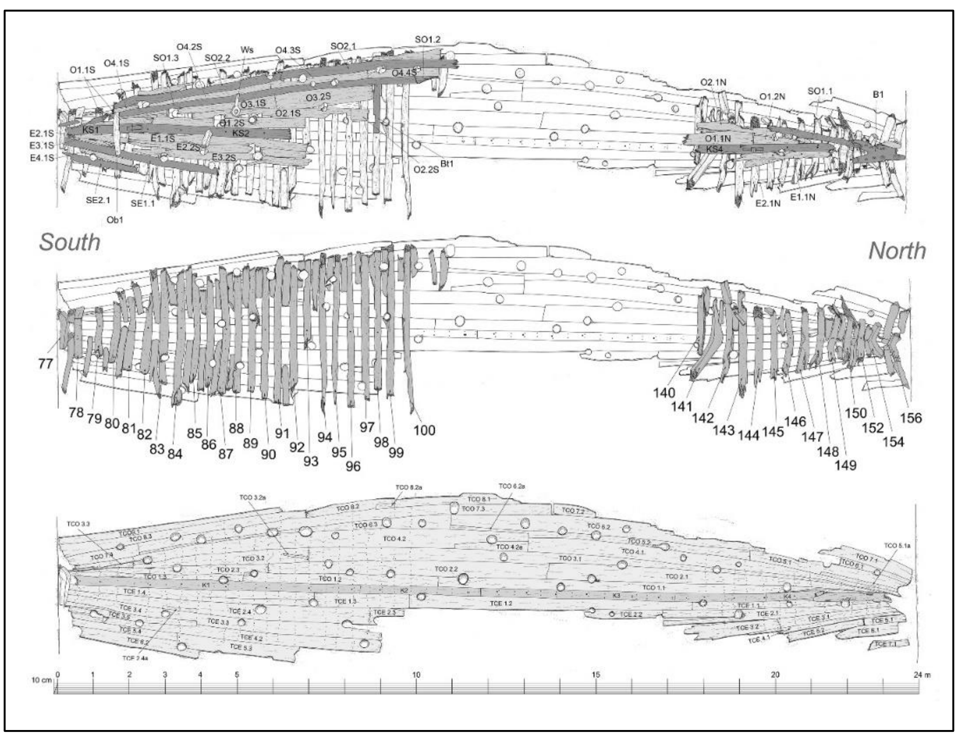



Figure 7 – Cais do Sodré Wreck (Castro et al. 2011).

***Example of a table with the timber inventory:***

| Ref. | Location | Length pres. | Length rec. | Sided [cm] | Molded [cm] |
|---|---|---|---|---|---|
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

5. A fiche per timber with the following basic information:
    a. Reference (tag);
    b. Additional location information, e.g. square, layer, or depth (if necessary).
    c. Date recorded and signature;
    d. Sketch;
    e. Length preserved;
    f. Length reconstructed (when possible);
    g. Sided dimension;
    h. Molded dimension;
    i. Carpenter (construction) marks;
    j. Scarves;
    k. Fasteners (type, dimensions, timbers connected);
    l. Tool marks;
    m. Wood species;
    n. Timber conversion, including ring-width average and growth pattern;
    o. Samples;
    p. Additional comments.

This information can be entered directly in a computer, or recorded on paper, in a fiche like the one presented below, and can be completed with additional drawings and sketches.

# Timber Recording Sheet

Date: ___________________

Author: _________________

Reference (tag no.): ________________ Position: ____________________

Sketch:

Length preserved: ___________m
Length reconstructed: ________m

Sided dimension: ___________cm
Molded dimension: _________cm

Wood species: ________________
Samples (no.): ________________

Section / Conversion:

Scarves:

Fasteners:

Carpenter (construction) marks:

Coatings/paints/sheathing:

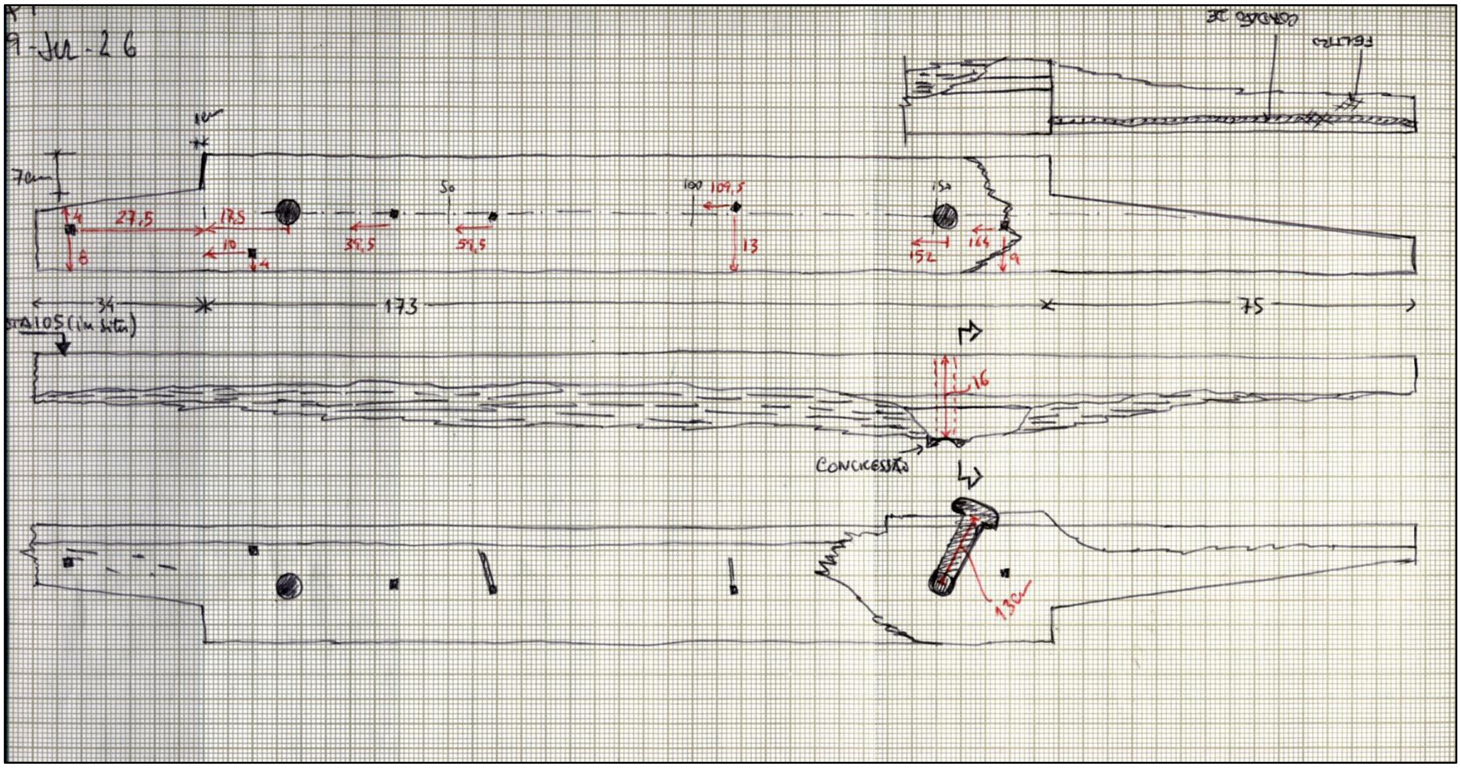
Bevels:

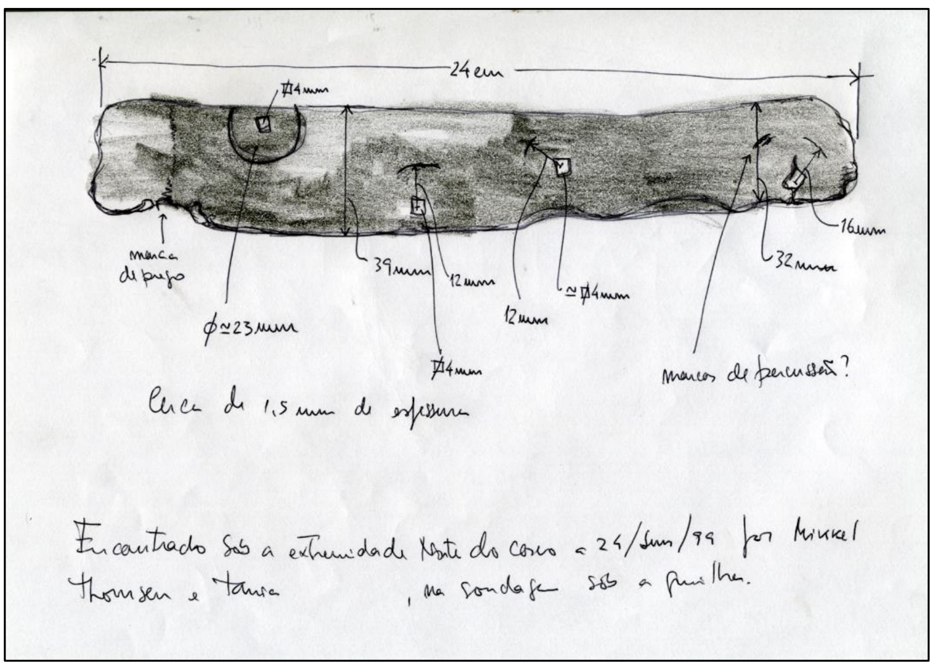
Additional Comments:

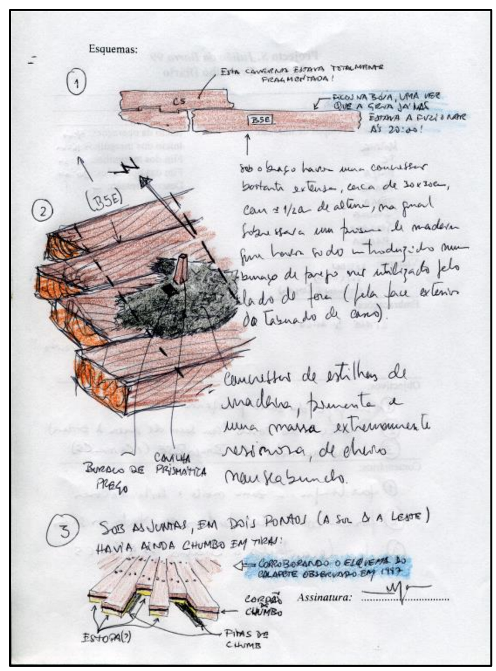
# Additional Sketches

Date: ________________

Author: ________________





All additional drawings and sketches should be scanned and filed.

6. A drawing of the timber containing:

   a. Four views and at least one section;
   b. Shape;
   c. Comments.

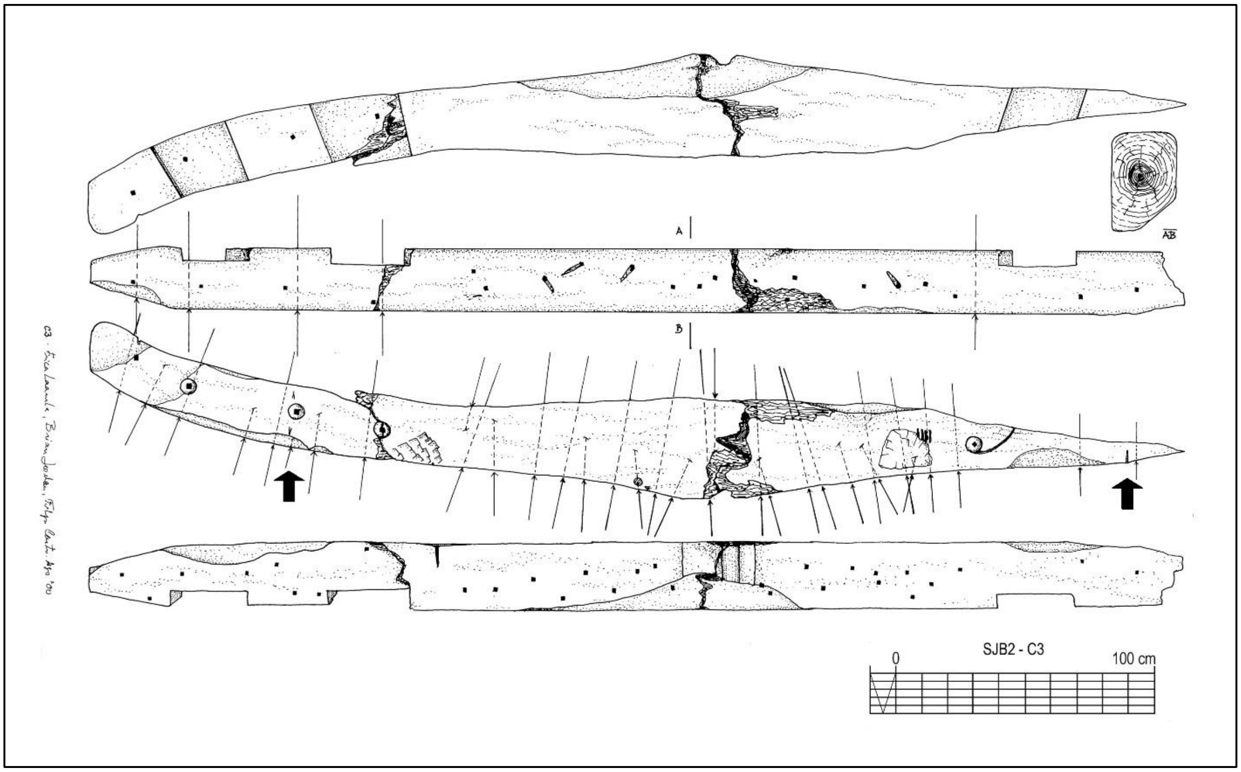



Figure 8 – Pepper Wreck (Castro 2002).

7. A folder with images and scanned measurements and sketches.

8. The main hull components to be considered in the elaboration of the timber catalogue are indicated below:

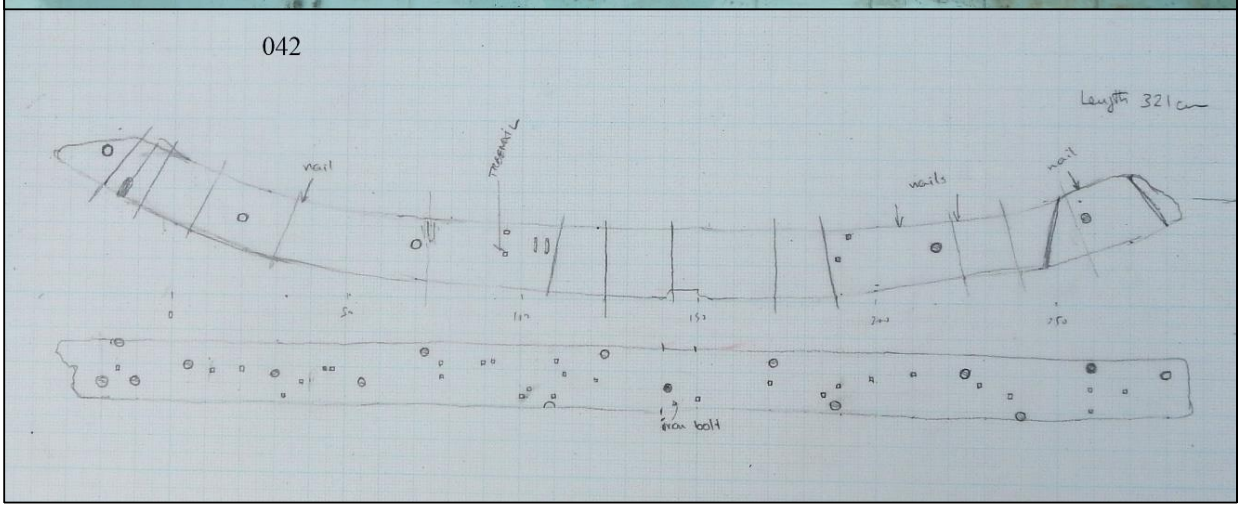
   a. Keel;
   b. False keel;
   c. Stem;
   d. Stem heel;
   e. Apron;
   f. Sternpost;
   g. Stern heel;
   h. Stern knee;
   i. Floor timbers;
   j. Half frames;
   k. Futtocks;
   l. Keelson;
   m. Maststep;
   n. Garboards;
   o. Planking

p. Stringers;
q. Ceiling;
r. Riders;
s. Wales;
t. Clamps
u. Knees;
v. Waterways;
w. Beams, carlings, and ledges;
x. Deck planking;
y. Hatch coamings;
z. Stanchions, bitts, pumps and sumps, rigging, and other features

9. If raised, individual timbers can be recorded in many different ways, ranging from the traditional 1:1 hand drawings in transparent film (Figure 9) to direct scaling, by placing the timber over a grid (Figures 10 and 11). Again, computers are simplifying the recording process and timbers can be recorded using photogrammetry (Figure 12), or scanned with laser technology (Figures 21 and 23).

It is fundamental to take scaled pictures of every surface and every detail.

Figure 9 – Recording the Arade 1 timbers on a horizontal plane, using a laser and transparent film (Photo: Filipe Castro).




Figures 10 and 11 – Recording the Belinho 1 timbers on a horizontal plane, using a 10 x 10 cm grid underneath and recording it directly on millimetric paper, at a 1:10 scale (Drawing and photo: Filipe Castro).

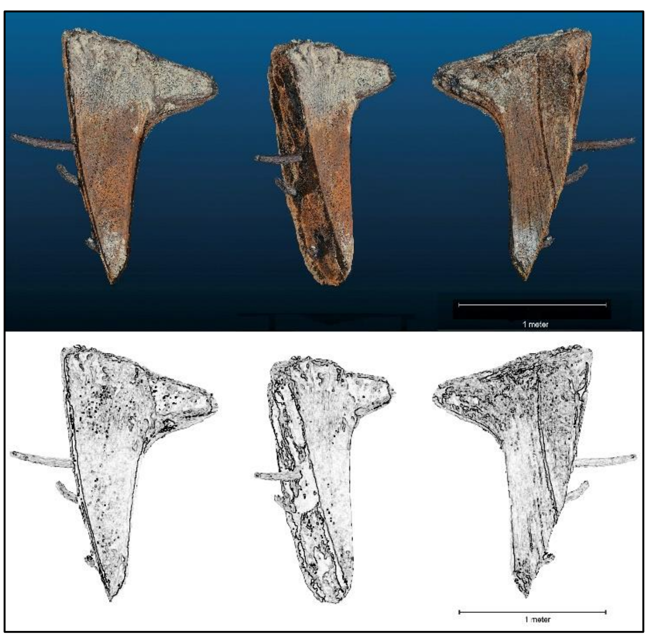



Figure 12 – Tridimensional model obtained with photogrammetry (PhotoScan). There are a few basic rules to simplify and streamline this process, namely controlling the light and setting the timbers on a surface that can be easily edited out of the pictures (Torres et al. 2017).

When timbers are recorded in situ the traditional way is to make sketches and take measurements by hand. Curvature is very important and there are several simple ways to record it, the most common being:

1. Manual goniometer: as shown in Figures 13, 14 and 15, this method consists of measuring the distance between two points, which make the third side of an isosceles triangle. The archaeologist places one of the sides along the curve to be recorded, moves the second side to the horizontal position, with the help of a level, and measures the third side of the triangle. This method requires that you know the position of the goniometer along the curve that you are recording.

2. Digital goniometer: this method is similar to the previous one but simpler, because electronic goniometers record the angle to the horizontal (Figures 16, 17, 18, and 19).

3. Offsets: this method is simple and easy for short curves and consists of a horizontal bar set over vertical poles, with a tape measure glued to it, representing the 'x' axis. The vertical 'y' measurements are taken with a tape measure with a plumb on the bottom (Figure 20).

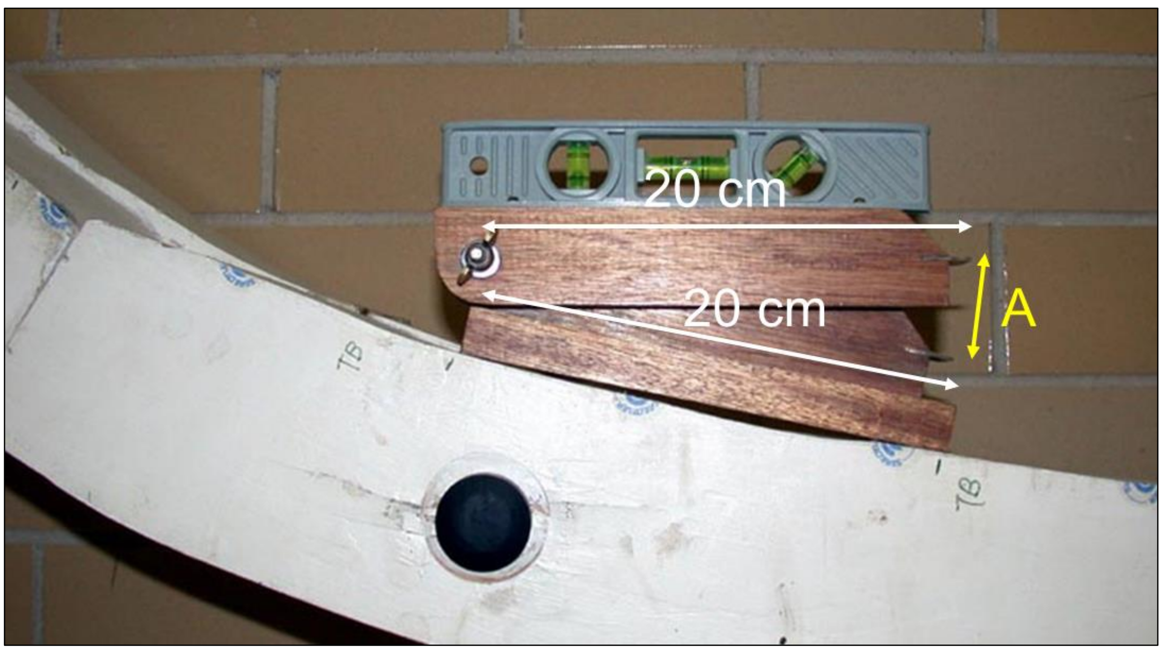



Figure 13 – Manual goniometers are a quick and accurate way to retrieve slopes and capture curves (Photo: Filipe Castro).

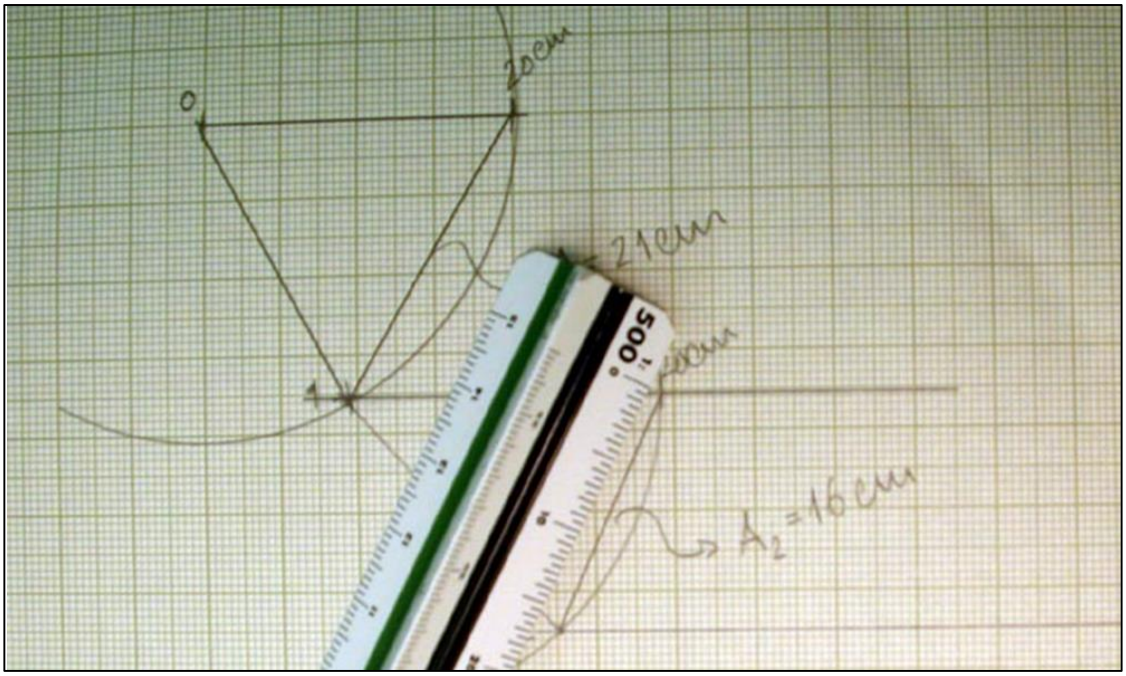



Figure 14 – Points 0, 1, 2, etc., are spaced 20 cm (the length of the goniometer) and define the curve recorded (Photo: Filipe Castro).

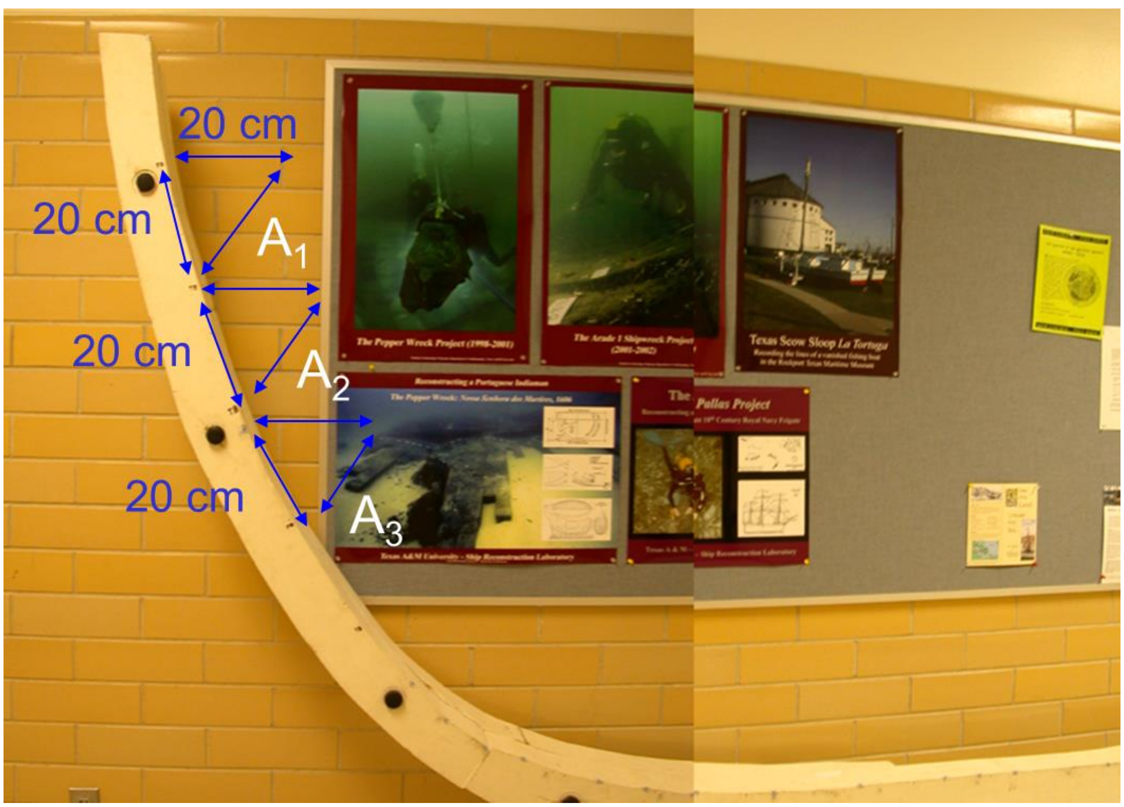



Figure 15 – Taking the curve of a replica of a frame from the 1686 French shipwreck *Belle* (Photo: Filipe Castro).


Figure 16 – Digital goniometer (Photo: Filipe Castro).

Figure 17 – Dry case for a digital goniometer (Photo: Filipe Castro).

The digital goniometer must be mounted on a base with a known distance, so that the angles can be accurately plotted on each incremental distance.

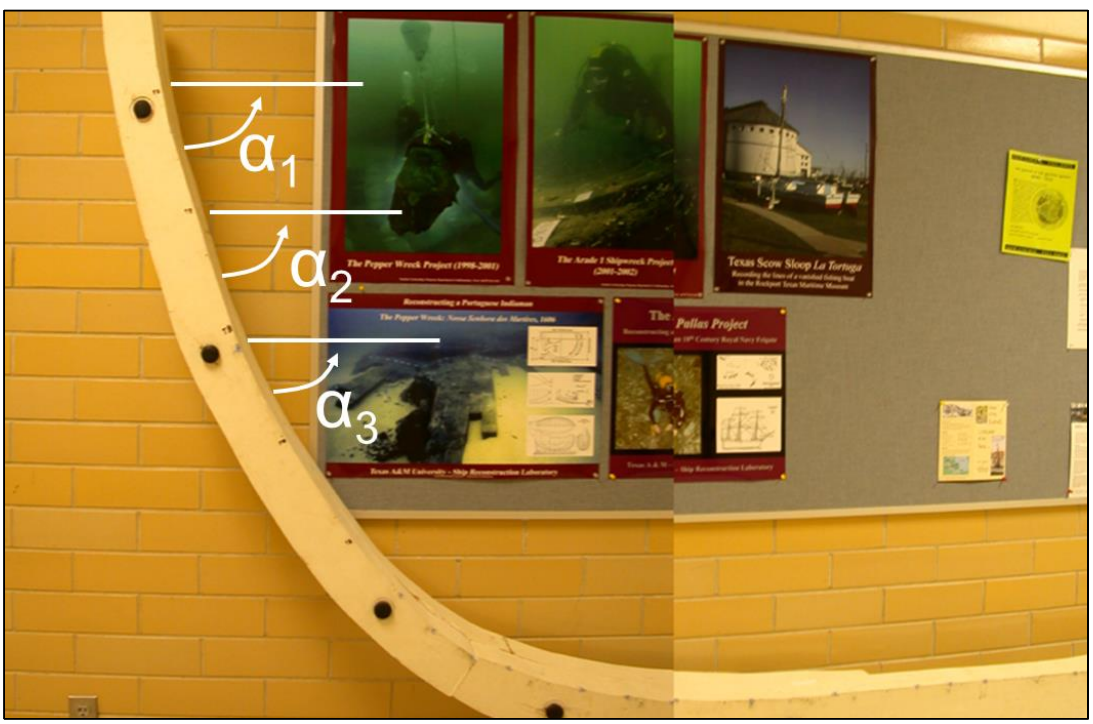



Figure 18 – Taking the curve of a replica of a frame from the 1686 French shipwreck *Belle* with an electronic goniometer (Photo: Filipe Castro).

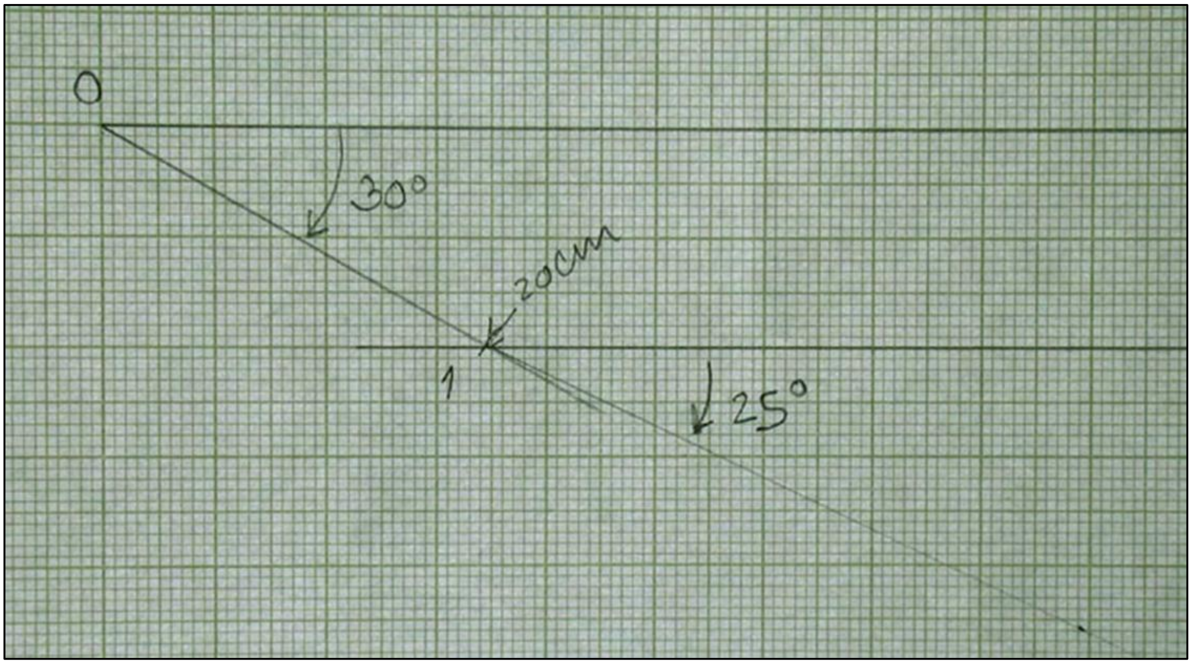



Figure 19 – Points 0, 1, etc., are spaced the distance of the base on which the digital goniometer is mounted define the curve recorded (Photo: Filipe Castro).

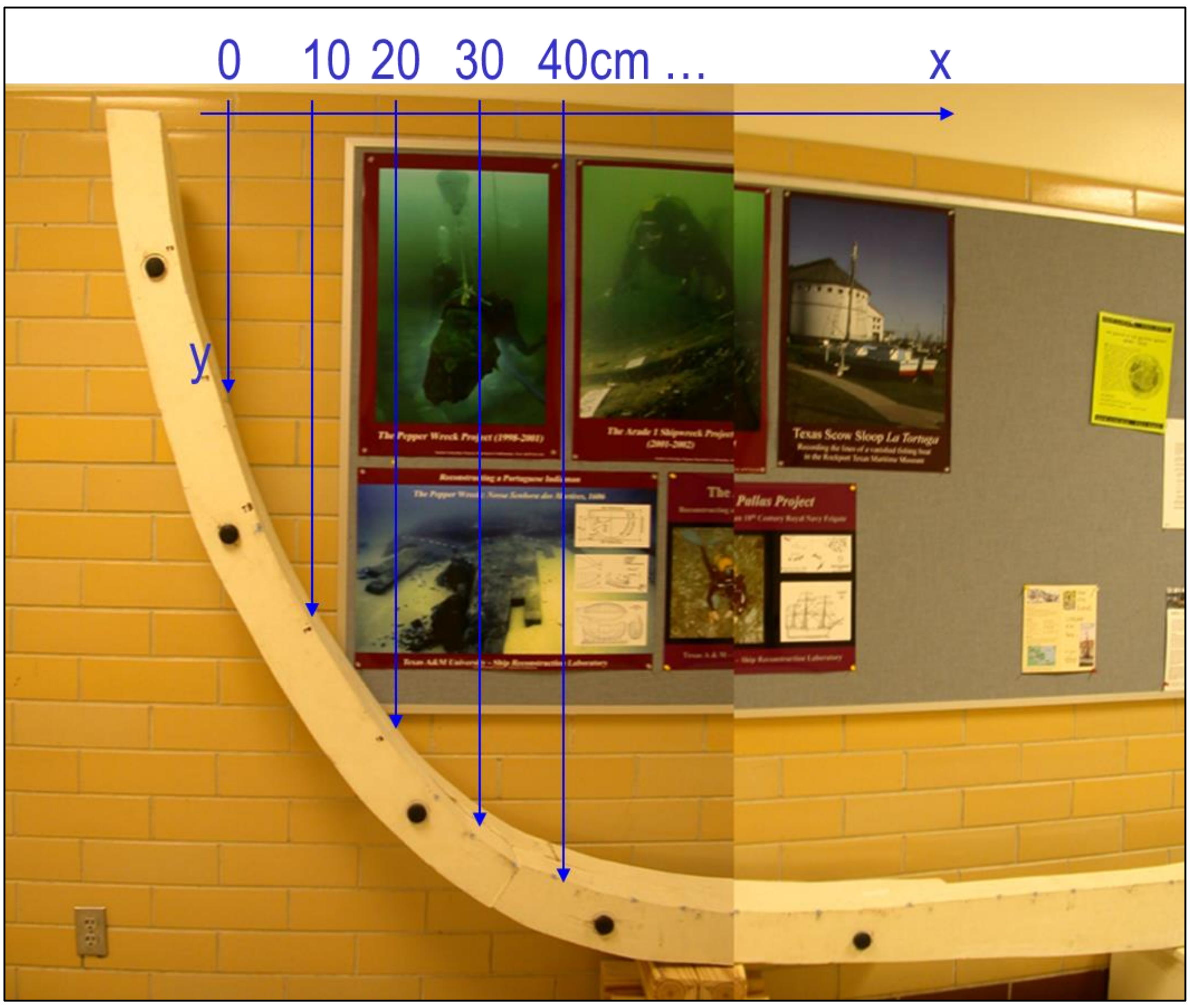



Figure 20 – Taking the curve of a replica of a frame from the 1686 French shipwreck *Belle* with offsets from an horizontal line (Photo: Filipe Castro).

10. When documenting disarticulated ship timbers via laser scanning, the resolution of the laser scanner will determine the additional information needed for adequate documentation of the timbers. Assuming sufficient resolution, some of the details normally recorded by hand are easily discernible, such as wood grain patterns and direction, treenail locations, and markings. At the Conservation Research Laboratory (CRL), laser scanned models of timbers are incorporated into the documentation of the vessel in three ways.

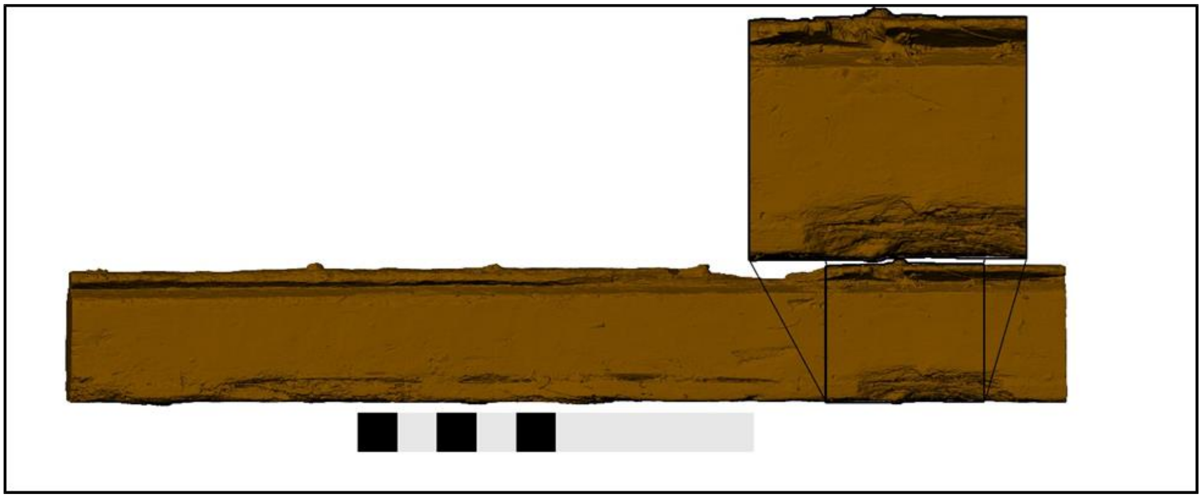


Figure 21: Laser scan section of the keel from the 18-century ship from Alexandria, VA. The resolution of the scan is high enough to pick out the grain pattern, erosion, and fasteners in the wood (Image: Chris Dostal).

First, the models themselves are always included. Ideally, online hosting with open access and the ability to download the models is utilized to facilitate complimentary research and critiques. At a minimum, a non-proprietary version of the models should be available upon request.

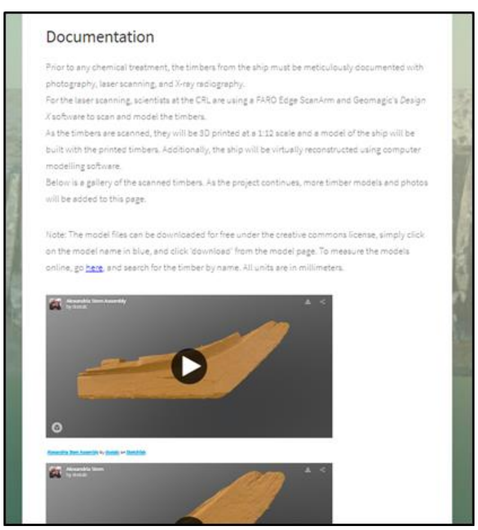



Figure 22: Downloadable 3D files for the 18th-Century Alexandria Ship Project hosted on the CRL website. The models can be manipulated directly in a browser, allowing for easy access to researchers (Image: Chris Dostal).

A researcher having the ability to manipulate the 3D model of each individual timber greatly increases the reliability of the data by reducing several of the layers of interpretation necessary for traditionally recorded timbers. When recording the sided and molded dimensions of a particular futtock for example, the person doing the recording has to determine where one face ends and the next starts; this is obvious when dealing with a very squared timber, but for timbers with rounded sides, a semi-arbitrary demarcation point is necessary. With a manipulatable 3D model of a timber, no such arbitrary demarcation point needs to be established.

The second way to incorporate a laser scanned 3D model of a timber is to use the model to develop a timber drawing with the 4-5 faces traditionally included for timber drawings. If the manipulatable 3D model is not part of the documentation for the project, cross section views are needed to show the shape of the timber. If the model is included, the shape can be more precisely seen by rotating the model. Color and lighting settings in the software are crucial to the success of this process. The color should be chosen to roughly approximate reality but off enough that it is clear to the reader that it is not original to the wood. The lighting must be consistent for each of the faces and should be adequate to not obscure details.


Figure 23: Orthogonal views of a laser scanned timber (Image: Chris Dostal).

The third way to incorporate laser scanned models is to use the model as a starting point for a more traditional style drawing. We do this to create simplified drawings that can focus attention on specific details, like fasteners, cracks, dubbing marks, tool marks, concretions, etc. To accomplish this, the outline of the model at each face is created, and then that outline is used as the boundary for the drawing. The faces of the model as seen in Figure 23 are then printed out and drawn over while inspecting the physical timber and drawn in atop the image. Everything noted is then traced in using CAD software.

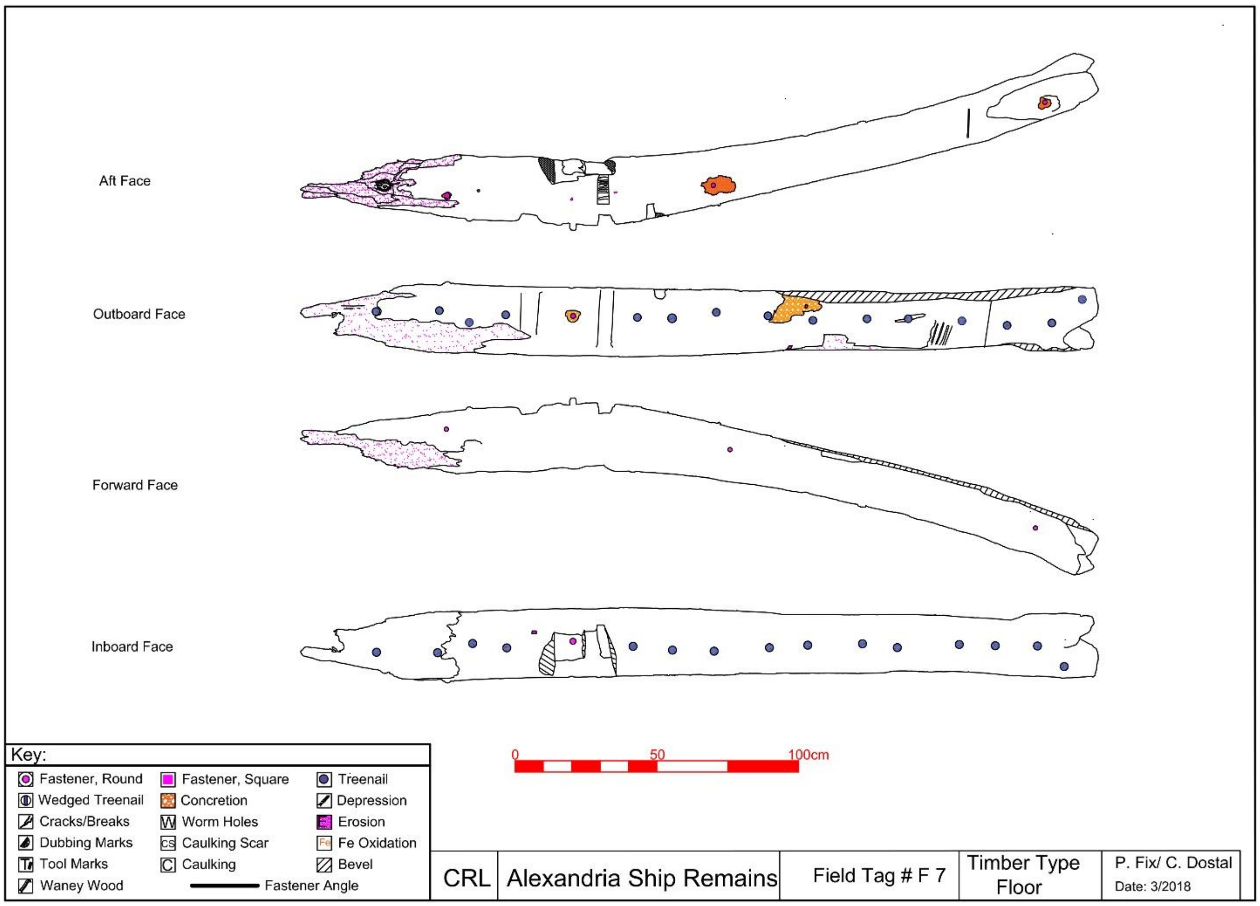



Figure 24: Timber from the Alexandria Ship (Image Peter Fix and Chris Dostal, CMAC/TAMU).

11. The parameters to be recorded in each timber indicated above is detailed below, in the following pages:

**a. Keel**

1. Length preserved;
2. Length reconstructed;
3. Shape;
4. Number of components;
5. Scarves;
6. False keels or rising timbers;
7. Section geometry;
8. Rabbets;
9. Sided and molded dimensions at bow, amidships and stern, as applicable;
10. Fasteners: between components, Keel/Stem or Stem knee, Keel/Apron, Keel/Sternpost or Stern knee, Keel/Stern Heel, Keel/keelson;
11. Calking in the scarf tables;
12. Wood type;
13. Conversion;
14. Construction marks;
15. Tool marks;
16. Coatings;
17. Additional comments.

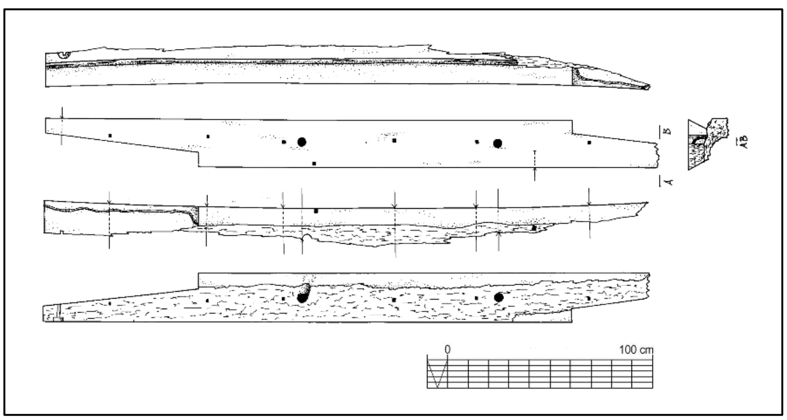



Figure 25 – Fragment of a keel section from the Pepper Wreck (Castro 2002).

**b. False keel**

1. Length preserved;
2. Length reconstructed;
3. Shape;
4. Number of components;
5. Scarves;
6. Section geometry;
7. Sided and molded dimensions at bow, amidships and stern, as applicable;
8. Fasteners;
9. Wood type;
10. Conversion;
11. Construction marks;
12. Tool marks;
13. Coatings;
14. Additional comments.

**c. Stem**

1. Length preserved;
2. Length reconstructed;
3. Shape;
4. Number of components;
5. Scarves;
6. False Stems and other associated timbers;
7. Section geometry;
8. Rabbets;
9. Sided and molded dimensions at heel and head, as applicable;
10. Fasteners;
11. Wood type;
12. Conversion;
13. Construction marks;
14. Tool marks;
15. Coatings;
16. Additional comments.

**d. Stem heel**

1. Length preserved;
2. Length reconstructed;
3. Shape;
4. Scarves;
5. Aprons and associated timbers;
6. Section geometry;
7. Rabbets;
8. Sided and molded dimensions at heel and head, as applicable;
9. Fasteners;
10. Wood type;
11. Conversion;
12. Construction marks;
13. Tool marks;
14. Coatings;
15. Additional comments.

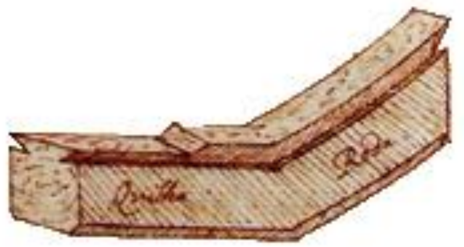


Figure 26 – Stem heel (Lavanha c. 1600).

**e. Apron**

1. Length preserved;
2. Length reconstructed;
3. Shape;
4. Scarves;
5. Associated timbers;
6. Section geometry;
7. Sided and molded dimensions at heel and head, as applicable;
8. Fasteners;
9. Wood type;
10. Conversion;
11. Construction marks;
12. Tool marks;
13. Coatings;
14. Additional comments.

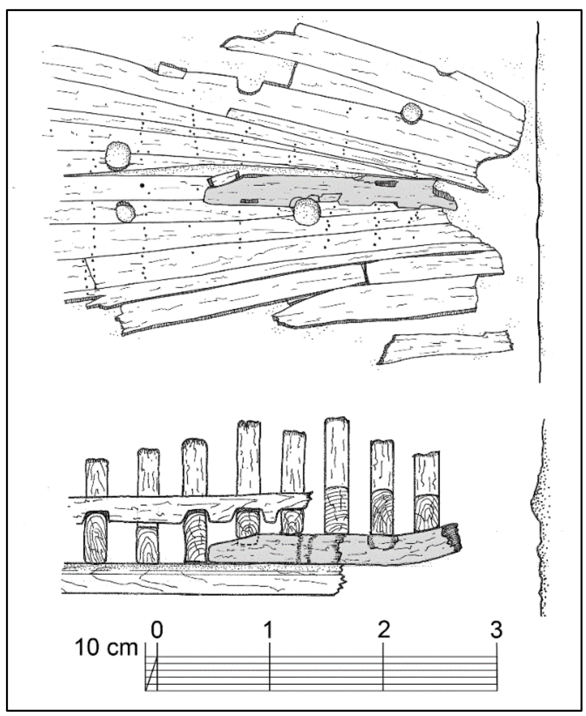



Figure 27 – Cais do Sodré Wreck (Castro et al. 2011).

**f. Sternpost**

1. Length preserved;
2. Length reconstructed;
3. Shape;
4. Number of components;
5. Scarves;
6. False Sternposts, fashion timbers and other associated timbers;
7. Section geometry;
8. Rabbets;
9. Sided and molded dimensions at heel and head, as applicable;
10. Fasteners;
11. Wood type;
12. Conversion;
13. Construction marks;
14. Tool marks;
15. Coatings;
16. Additional comments.

**g. Stern heel**

1. Length preserved;
2. Length reconstructed;
3. Shape;
4. Scarves;
5. Associated timbers;
6. Section geometry;
7. Rabbets;
8. Sided and molded dimensions at heel and head, as applicable;
9. Fasteners;
10. Wood type;
11. Conversion;
12. Construction marks;
13. Tool marks;
14. Coatings;
15. Additional comments.

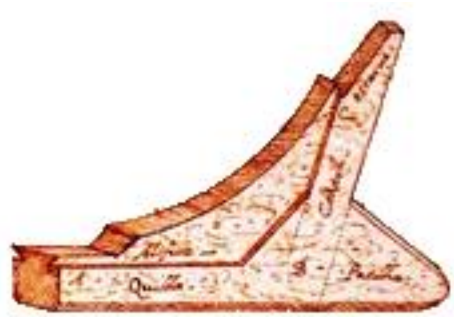


Figure 28 – Stern heel (Lavanha c. 1600).

## h. Stern knee

1. Length preserved;
2. Length reconstructed;
3. Shape;
4. Scarves;
5. Associated timbers;
6. Section geometry;
7. Sided and molded dimensions at heel and head, as applicable;
8. Fasteners;
9. Wood type;
10. Conversion;
11. Construction marks;
12. Tool marks;
13. Coatings;
14. Additional comments.

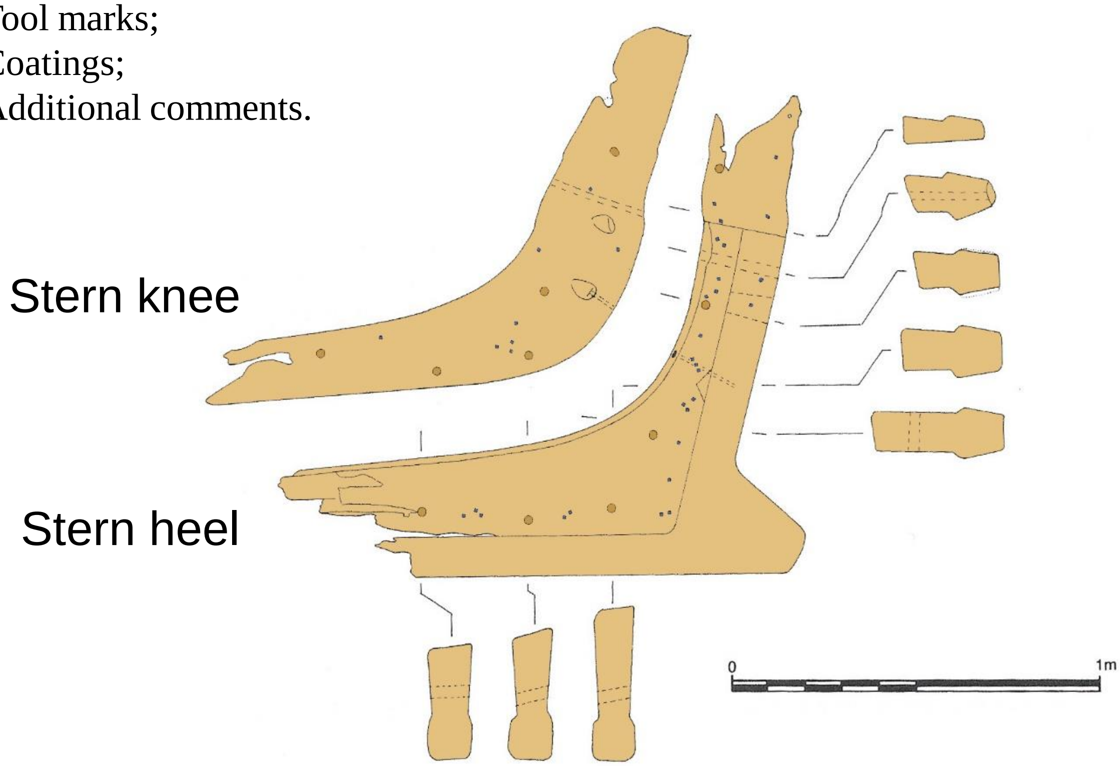



Figure 29 – Corpo Santo (Drawing: Miguel Aleluia).

**i. Floor timbers** **j. Half frames** **k. Futtocks**

1. Framing plan;
2. Section geometry;
3. Locations and dimensions of limber holes;
4. Sided and molded dimensions (max., min, av.) at keel and intermediate dimensions, as applicable;
5. Room and space, the distance between frame centers (max., min, av.);
6. Scarves and chocks;
7. Fasteners: floors/Keel, floors/futtocks;
8. Wood type;
9. Conversion;
10. Shape;
11. Bevels;
12. Construction marks;
13. Tool marks;
14. Coatings;
15. Additional comments (e.g. inclination, square or canted, etc.).

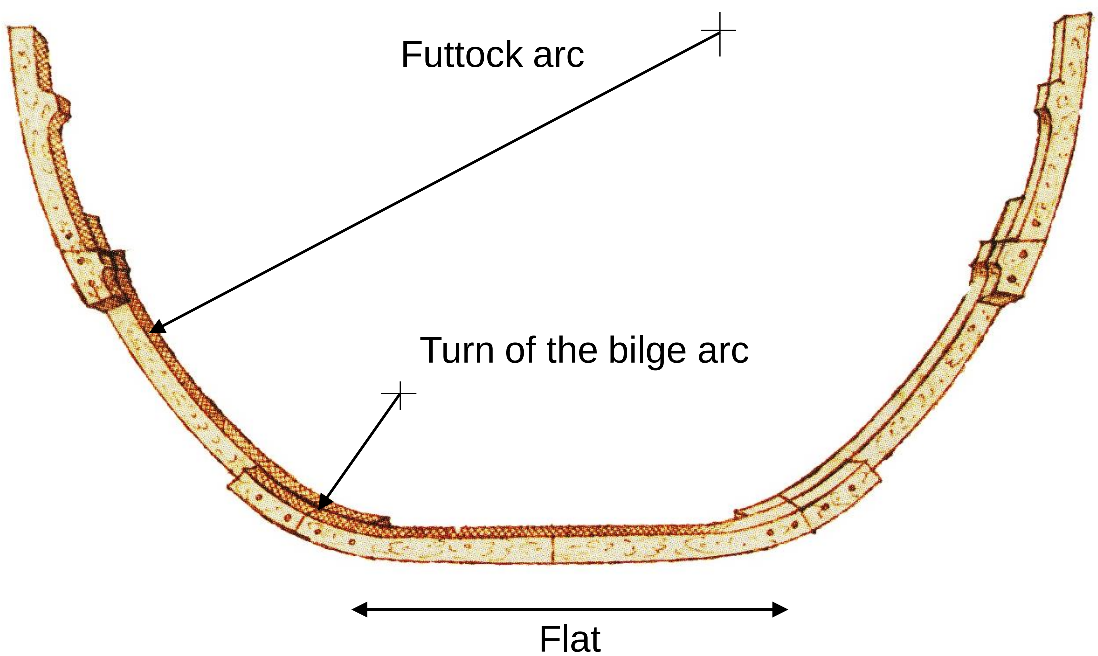



Figure 30 – Stern heel (Lavanha c. 1600).

**i. Floor timbers** **j. Half frames** **k. Futtocks**


Figure 31 – Frame (Lavanha c. 1600).

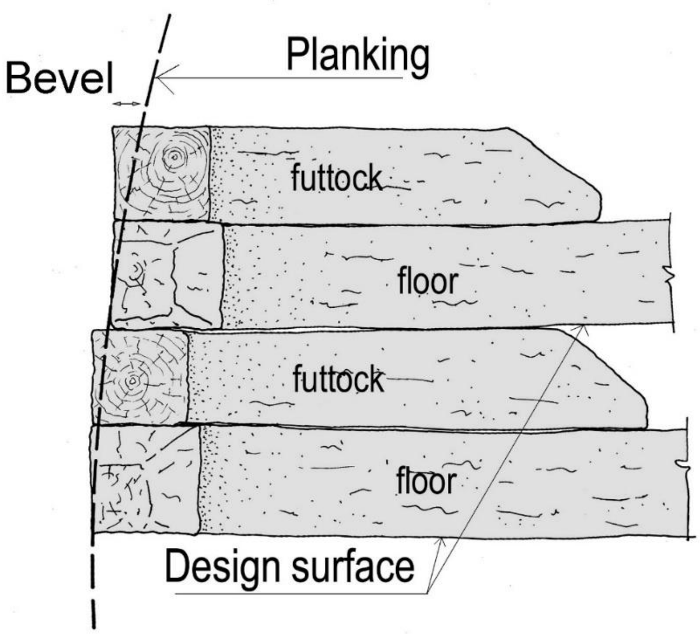



Figure 32 – Pepper Wreck (Drawing: Filipe Castro).

11. Bevels: all frames are beveled to receive the planking, and if properly measured, the bevels can be used to check the shape of the diagonals and water lines in the reconstruction phase.

**l. Keelson**

1. Length preserved;
2. Length reconstructed;
3. Shape;
4. Scarves;
5. Notched over floor timbers;
6. Mortises;
7. Sided and molded dimensions at bow, amidships and stern, as applicable;
8. Fasteners;
9. Wood type;
10. Conversion;
11. Construction marks;
12. Tool marks;
13. Coatings;
14. Additional comments.

**m. Maststeps and butresses**

1. Length preserved;
2. Length reconstructed;
3. Shape;
4. Number of components;
5. Scarves;
6. Notched over floor timbers;
7. Mortises for masts, stanchions and other cuttings;
8. Section geometry;
9. Sided and molded dimensions at bow, amidships and stern, as applicable;
10. Fasteners;
11. Wood type;
12. Conversion;
13. Construction marks;
14. Tool marks;
15. Coatings;
16. Additional comments.

## n. Garboards

1. Length preserved;
2. Length reconstructed;
3. Shape;
4. Number of components;
5. Scarves;
6. Section geometry;
7. Sided and molded dimensions, as applicable;
8. Fasteners;
9. Wood type;
10. Conversion;
11. Construction marks;
12. Tool marks;
13. Coatings;
14. Additional comments.

## o. Planking

1. Planking plan, number of strakes;
2. Length preserved;
3. Length reconstructed;
4. Shape, hoods, and scarves;
5. Sided dimensions and thickness, as applicable;
6. Fasteners;
7. Wood type;
8. Conversion;
9. Construction marks;
10. Tool marks;
11. Caulking;
12. Coatings;
13. Sheathing: thickness and sheets' shapes and position, tucking around posts and keel;
14. Additional comments.

## p. Stringers and breast hooks

1. Length preserved;
2. Length reconstructed;
3. Shape;
4. Number of components;
5. Scarves;
6. Section geometry;
7. Sided and molded dimensions, as applicable;
8. Fasteners;
9. Wood type;
10. Conversion;
11. Construction marks;
12. Tool marks;
13. Coatings;
14. Additional comments.

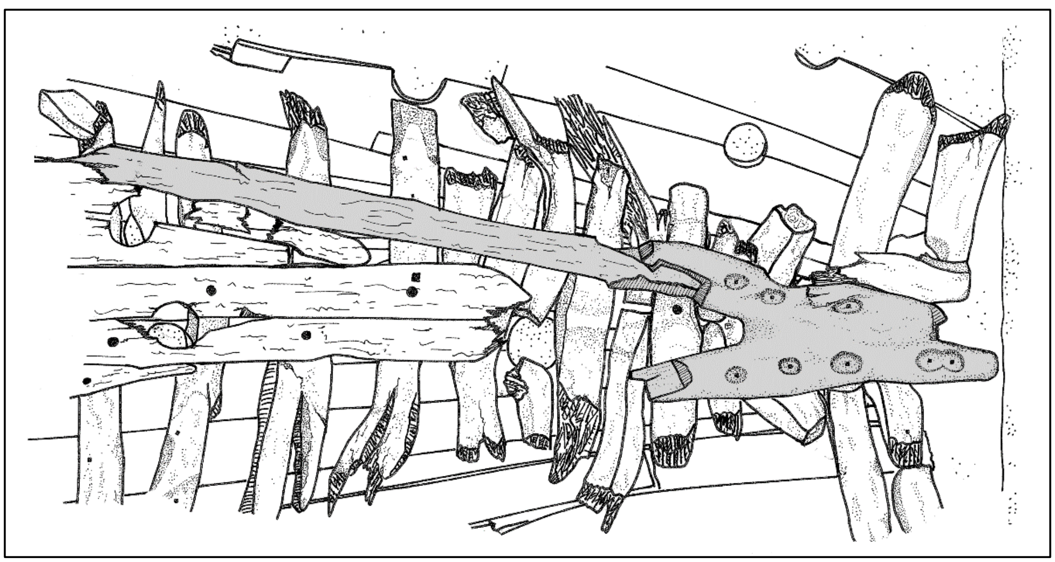


Figure 33 – Cais do Sodré Wreck (Castro et al. 2011).

**q. Ceiling**

1. Length preserved;
2. Length reconstructed;
3. Shape;
4. Sided dimensions and thickness, as applicable;
5. Fasteners;
6. Wood type;
7. Conversion;
8. Construction marks;
9. Tool marks;
10. Coatings;
11. Limber boards:
12. Additional comments.

**r. Riders**

1. Framing plan;
2. Section geometry;
3. Locations and dimensions of limber holes;
4. Sided and molded dimensions (max., min, av.) at keel and intermediate dimensions, as applicable;
5. Room and space (max., min, av.);
6. Scarves and chocks;
7. Fasteners: floors/Keel, floors/futtocks;
8. Wood type;
9. Conversion;
10. Shape;
11. Bevels;
12. Construction marks;
13. Tool marks;
14. Coatings;
15. Additional comments (e.g. inclination, square or canted, etc.).

**s. Wales**

1. Length preserved;
2. Length reconstructed;
3. Shape;
4. Number of components;
5. Scarves;
6. Section geometry;
7. Sided and molded dimensions, as applicable;
8. Fasteners;
9. Wood type;
10. Conversion;
11. Construction marks;
12. Tool marks;
13. Coatings;
14. Additional comments.

**t. Clamps**

1. Length preserved;
2. Length reconstructed;
3. Shape;
4. Number of components;
5. Scarves;
6. Section geometry;
7. Sided and molded dimensions, as applicable;
8. Fasteners;
9. Wood type;
10. Conversion;
11. Construction marks;
12. Tool marks;
13. Coatings;
14. Additional comments.

**u. Knees**

1. Length preserved;
2. Length reconstructed;
3. Shape;
4. Scarves;
5. Section geometry;
6. Sided and molded dimensions, as applicable;
7. Fasteners;
8. Wood type;
9. Conversion;
10. Construction marks;
11. Tool marks;
12. Coatings;
13. Additional comments.

**v. Beams, carlings, and ledges**

1. Length preserved;
2. Length reconstructed;
3. Shape;
4. Scarves;
5. Section geometry;
6. Sided and molded dimensions, as applicable;
7. Fasteners;
8. Wood type;
9. Conversion;
10. Construction marks;
11. Tool marks;
12. Coatings;
13. Additional comments.

**w. Waterways**

1. Length preserved;
2. Length reconstructed;
3. Shape;
4. Scarves;
5. Section geometry;
6. Sided and molded dimensions, as applicable;
7. Fasteners;
8. Wood type;
9. Conversion;
10. Construction marks;
11. Tool marks;
12. Coatings;
13. Additional comments.

**x. Deck planking**

1. Length preserved;
2. Length reconstructed;
3. Shape;
4. Sided dimensions and thickness, as applicable;
5. Fasteners;
6. Wood type;
7. Conversion;
8. Construction marks;
9. Tool marks;
10. Coatings;
11. Limber boards:
12. Additional comments.

**y. Hatch coamings**

1. Length preserved;
2. Length reconstructed;
3. Shape;
4. Section geometry;
5. Sided dimensions and thickness, as applicable;
6. Fasteners;
7. Wood type;
8. Conversion;
9. Construction marks;
10. Tool marks;
11. Coatings;
12. Limber boards:
13. Additional comments.

**z. Stanchions, bitts, pumps and sumps, rigging, and other features**

1. Length preserved;
2. Length reconstructed;
3. Shape;
4. Section geometry;
5. Sided dimensions and thickness, as applicable;
6. Fasteners;
7. Wood type;
8. Conversion;
9. Construction marks;
10. Tool marks;
11. Coatings;
12. Limber boards:
13. Additional comments.

**aa. Summary of the fasteners**

Even though this is a redundant section, it is useful to include a section on the fasteners, mentioning the fastening types, patterns and sizes:

| Timbers | Fasteners | Patterns |
|---|---|---|
| Keel sections | | |
| Keel / Posts | | |
| Floor timbers / keel | | |
| Keel / Keelson | | |
| Floor timbers / futtocks | | |
| Planking / floor timbers | | |
| Etc. | | |

Fastener types:

| Type | Section | Dimensions | Comments |
|---|---|---|---|
| Treenails | | | |
| Bolts | | | |
| Spikes | | | |
| Nails | | | |

Treenails are fashioned by hand, so they tend to have polygonal sections, bolts have generally round sections, and spikes and nails tend to have square sections in northern and western Europe, and round shanks along a portion of their length, changing to square near the heads. In the "Comments" column it is important to mention the shape of the tip and whether they are clenched or double clenched.

## ab. Tree morphology

All ships and boats are answers to a number of questions, and the quality and provenience of the timber are important factors to understand their shape, size and story. Forests and shipyards are connected and have influenced each other over time. Obtaining data about the ship timbers` parent trees and the employed conversion techniques allows gaining a better understanding of forest management. Including data collected from the vessel´s surviving timbers will constitute an added-value for the investigation of the wreck site and equally about the wood provenance, parent trees` morphologies, timber trade, timber transportation routes, timber conversion, timber assemblage, timber joinery and the hull shape and its requirements. Therefore, it becomes imperative to develop a methodology that intrinsically embodies a method in which shipbuilding can be analyzed in a broader context.

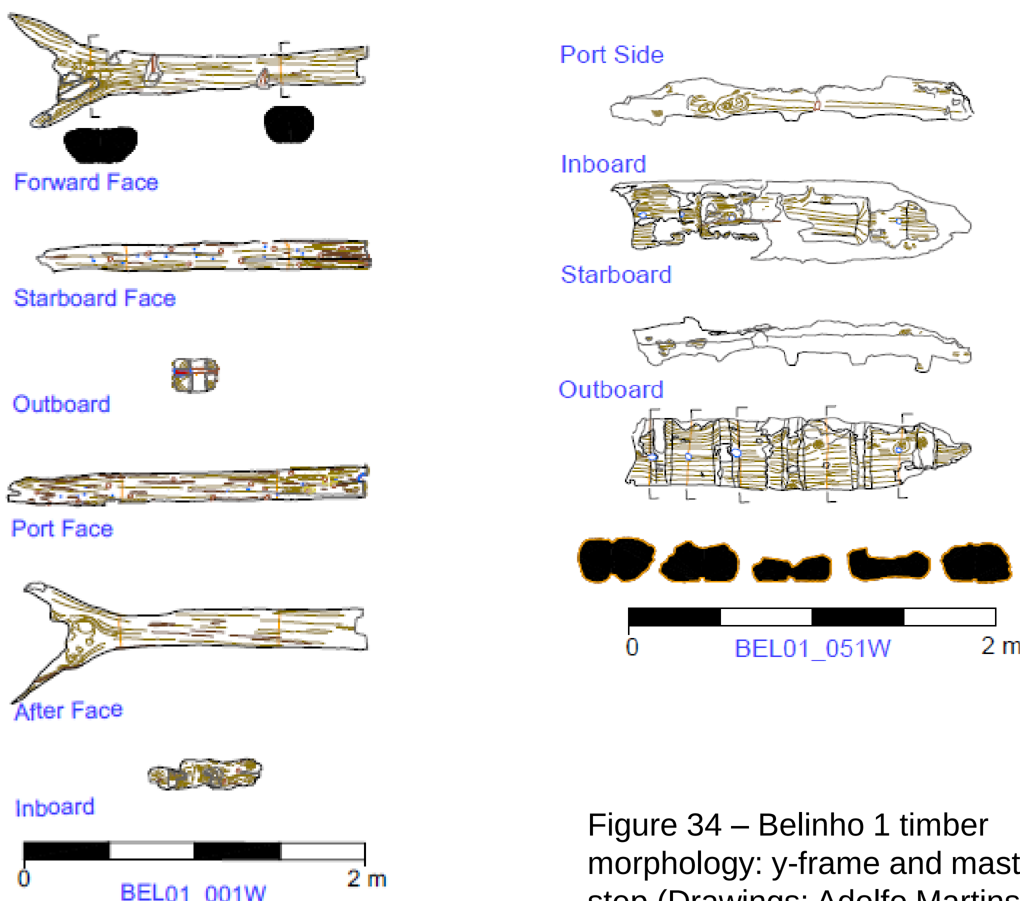



Figure 34 – Belinho 1 timber morphology: y-frame and masts step (Drawings: Adolfo Martins).

**References**

Castro, F., 2002. *The Pepper Wreck Timbers* – ShipLab Report 1.On file in Nautical Archaeological Program Library, Texas A&M University, 2002.

Castro, F., 2003. "The Pepper Wreck", *International Journal of Nautical Archaeology*, 32.1: 6-23.

Castro, F., 2005. "Archaeology and Dredges: the Arade River Archaeological Complex", *International Journal of Nautical Archaeology*, 34.1:72-83.

Castro, F., Yamafune, K., Eginton, C., and Derryberry, T., 2011. "The Cais do Sodré Shipwreck," in *International Journal of Nautical Archaeology* 40.2: 328-343.

Castro, F., Bendig, C., Bérubé, M., Borrero, R., Budsberg, N., Dostal, C., Monteiro, A., Smith, C., Torres, R., and Yamafune, K., 2017. "Recording, Publishing, and Reconstructing Wooden Shipwrecks" *Journal of Maritime Archaeology*. DOI: 10.1007/s11457-017-9185-8.

Dostal, C., 2018. *Laser Scanning as a Methodology for the 3-D Digitization of Archaeological Ship Timbers: a Case Study Using the World Trade Center Shipwreck*. Ph.D. Dissertation. College Station: Texas A&M University.

Drap, P. and Long, L., 2001. Towards a digital excavation data management system: the "Grand Ribaud F" Estruscan deep-water wreck. *Virtual Reality, Archeology, and Cultural Heritage*, 17-26.

Drap, P. et al., 2003. A photogrammetric process driven by an Expert System: A new approach for underwater archaeological surveying applied to the 'Grand Ribaud F' Etruscan wreck. *CVPR Workshops* 2003. Vol. 16.

Drap, P. et al., 2013. Underwater Photogrammetry for Archaeology. What Will Be the Next Step? *International Journal of Heritage in the Digital Era* , I.2: 375-394.

Drap, P., Merad, D., Hijazi, B., Gaoua, L., Nawaf, M., Saccone, M., Chemisky, B., Seinturier, J., Sourisseau, Gambin, T., and Castro, F., 2015. "Underwater photogrammetry and object modeling: a case study of Xlendi wreck in Malta," *Sensors* 15:12: 30351-30384.

Torres, R., 2015. *The Archaeology of Shore Stranded Shipwrecks of Southern Brazil*. Ph.D. Dissertation. College Station: Texas A&M University.

Torres, R., 2016. “Projeto Observabaía: Patrimônio Cultural Subaquático da Baía de Todos os Santos.” Relatório Parcial 2015. *Navigator: subsídios para a história marítima do Brasil*. Rio de Janeiro, 12(23): 140-153.

Torres et al. 2017. “Mapeando em Profundidade: A integração de técnicas digitais para a pesquisa arqueológica de sítios de naufrágios históricos.” *VESTÍGIOS Revista Latino-Americana de Arqueologia Histórica*. 11(1): 107-134.

Yamafune, K., Torres, R., Castro, F., 2017. “Multi-Image Photogrammetry to Record and Reconstruct Underwater Shipwreck Sites” for *Journal of Archaeological Method and Theory* 24.3: 703-725.

**Citation information:**
Filipe Castro, Charles Bendig, Marijo Bérubé, Ricardo Borrero, Nick Budsberg, Chris Dostal, Miguel Martins, Rodrigo Torres, Kotaro Yamafune, *Recording Early Modern Hull Remains*. College Station: Ship Reconstruction Laboratory, 2018

TEXAS A&M UNIVERSITY

UNIVERSIDAD DE LA REPÚBLICA URUGUAY

Prifysgol Cymru
Y Drindod Dewi Sant
University of Wales
Trinity Saint David

A.P.P.A.R.A.T.U.S. LLC

SHIPWRECK INSTITUTE

IRHMAS

Institut de Recherche en Histoire
Maritime et Archéologie Subaquatique

CMAC
Center for Maritime Archaeology & Conservation

J. Richard Steffy Ship Reconstruction Laboratory
ShipLAB
TEXAS A&M UNIVERSITY